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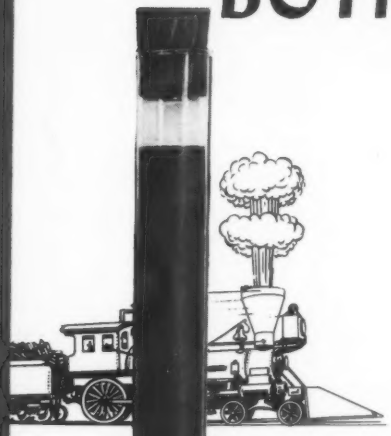

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MARCH

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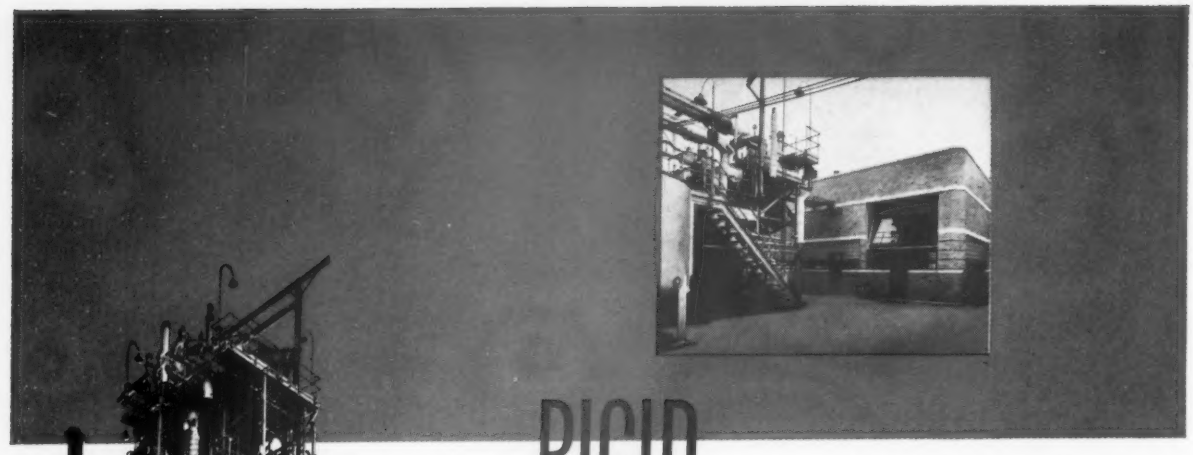
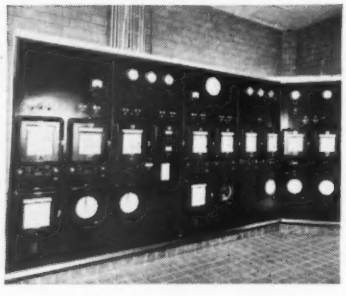


RIGID QUALITY CONTROL

Maleic anhydride processing unit, typical of RCI's integrated program of manufacturing many of its own basic raw materials.



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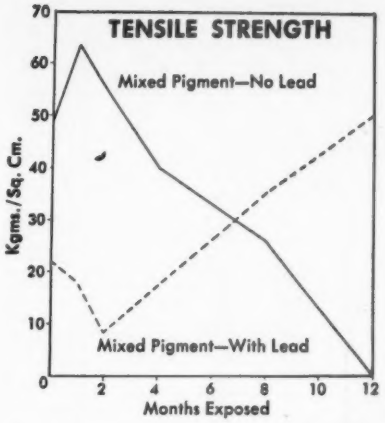
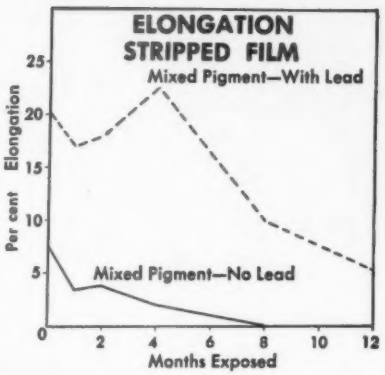


Strength-age graph shows how mixed pigment paint containing "lead" increases in tensile strength as it ages.



Elongation-age graph shows how the flexibility of a paint film is improved by the incorporation of "lead".

Photomicrograph showing the meshing of the spiney lead soap crystals.

"lead" adds elastic strength to a paint film

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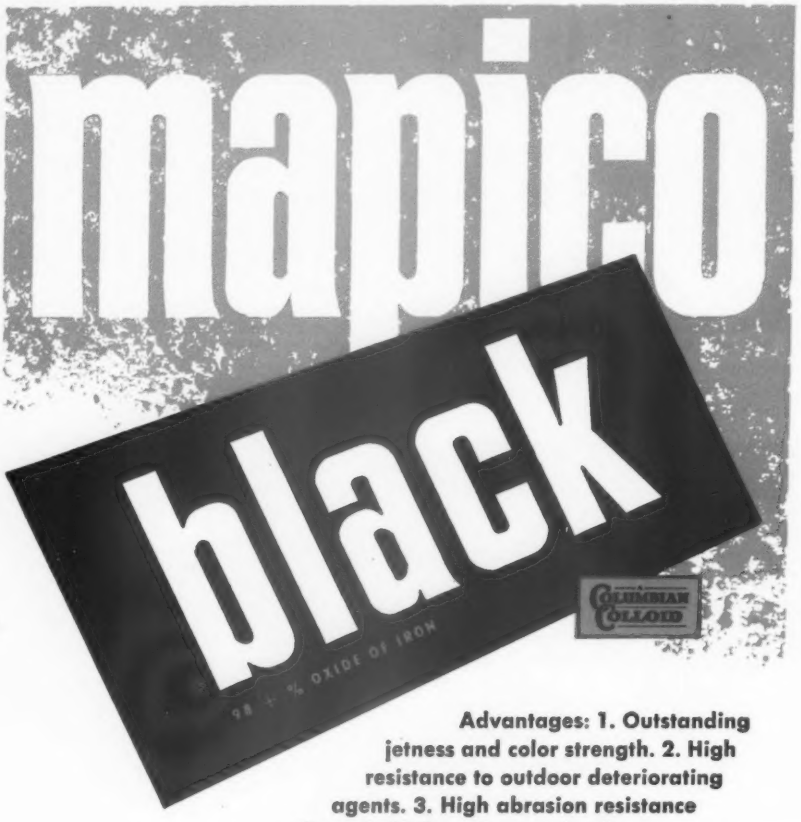

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PAINT and VARNISH Production

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VOL. 41 MARCH 1951 NO. 3

NEXT ISSUE

Coatings research as conducted by the Bureau of Ships will be presented in the next issue of Paint and Varnish Production. Such programs as surface preparation, ship bottom paints, flame spray application, vinyl coatings, coatings for submarines, coatings for gasoline tanks, silicones, fire retardant studies, and rust prevention will be covered and discussed.

FEATURES

Coatings for Protection of Steel in Water, *by G. W. Oxley* 10
Role of the Vehicle in Paints for Submerged Surfaces, *by A. C. Elm* .. 14
Importance of Surface Preparation for the Protection of Metals, *by A. J. Liebman* 18
Protective Coating for Submersible Type Transformers and Network Protectors, *by V. A. Veit* 27

DEPARTMENTS

Comment 9
New Products 31
News Digest 38
Technical Bulletins 40
Calendar of Events 41
Advertiser's Index 42

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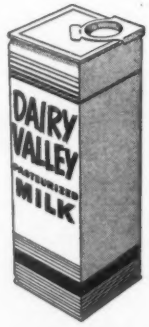

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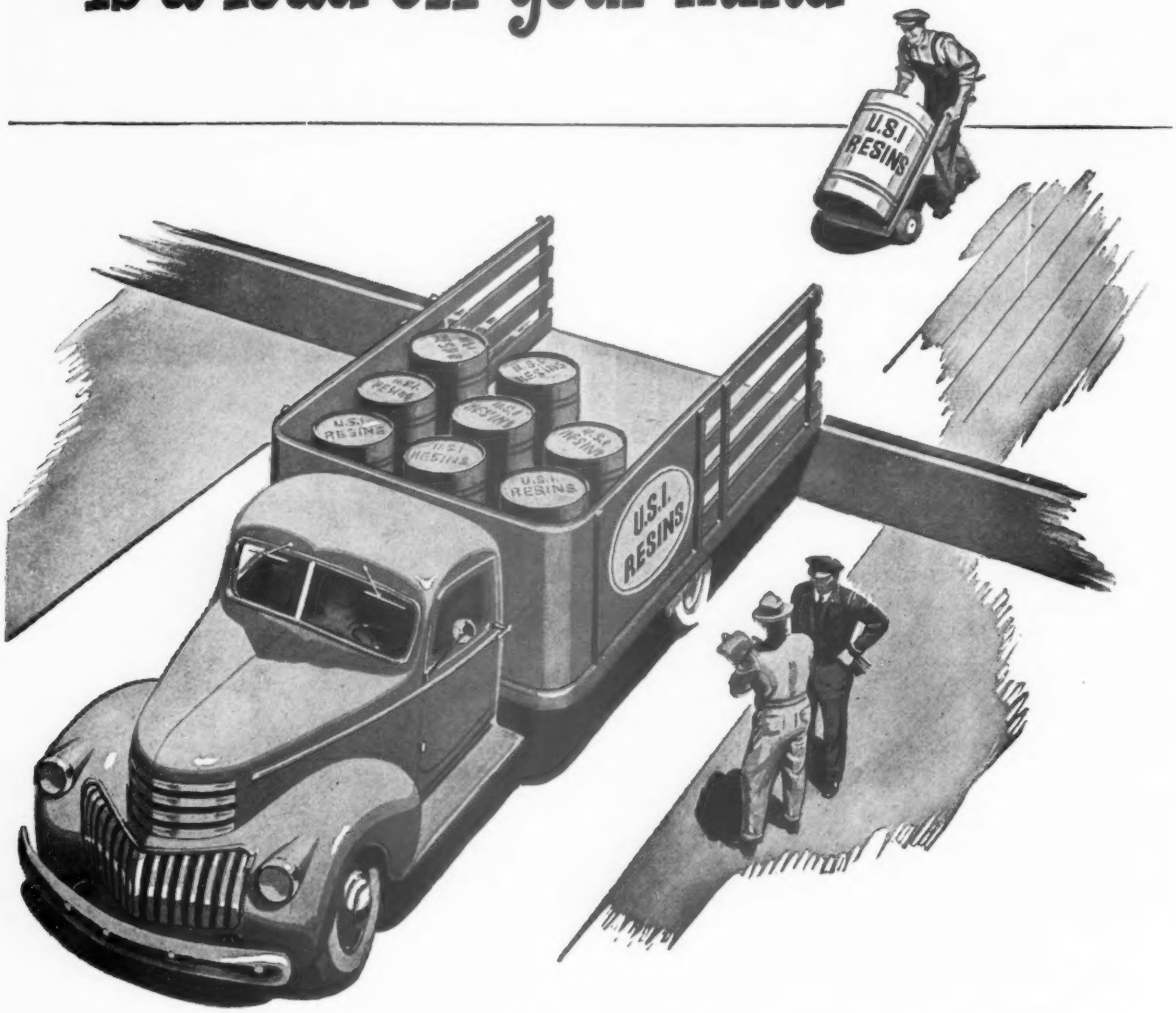

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Editorial Comment

Combatting Corrosion

AT THE colloquium on the Protection of Submersed Surfaces sponsored by the College of Engineering of New York University last November, Dr. Allen Alexander of the Naval Research Laboratory pointed out the great strides made in surface coating technology in combatting the constant problem of corrosion.

"Most materials of construction whether they be of metal or of some organic origin are highly susceptible to the influence of the degrading factors so widely abounding in nature. The deteriorating influence of water in both the liquid and gaseous phases, as it applies to metals in combination with oxygen is well known. As a result, major efforts of our engineers have been directed toward the design of effective measures to combat such influences. Through our own experience in the field of protective coatings, examples are noted that quite often elaborate methods of protection are devised to prohibit the oxidation of metal in corrosive atmospheres such as the application of electric current to render the metal passive or by the development of protective cathodic areas through the use of sacrificial anodes. Where such techniques are appropriate, for example, in areas submerged in water, the protection obtained thereby is often quite satisfactory. On the other hand, when such measures are inapplicable or for any reason ineffective, the remaining course almost inevitably appears to be the use of protective coatings quite often of an organic nature.

Since the application of protective organic coatings is relatively simple, it is only natural that they have been exploited to a high degree in this role. As a result, a wide variety of organic coatings have been developed which are available for application to a wide range of materials and products for highly specialized uses. As an example, the introduction of vinyl resins has placed in the hands of the coating formulator a matrix for carrying inhibitive pigments that is not susceptible to the influences of an alkaline surface to which it might be applied as are formulations based on certain of the vegetable drying oils. The development of a variety of inhibitive pigments has further strengthened the role of organic coatings in protecting metal surfaces from the ravages of corrosion. For example the availability of highly insoluble zinc yellow has made possible the development of the so-called wash primers which recently are finding such wide application in the protection of metallic surfaces to which it has been impossible heretofore to obtain adequate adhesion of the organic coating system."

In connection with the forthcoming Conference of the National Association of Corrosion Engineers, we are pleased to devote this month's issue of PAINT and VARNISH PRODUCTION to the various aspects of corrosion as related to protective coatings. Papers presented deal with such subjects as surface preparation for metals, coatings for protecting steel in water, coatings for subsoil installations, and the influence of the vehicle in paints for submerged surfaces.

Operation Survival

THE American Can research project known as "Operation Survival", which is concerned with the development of tinless cans has resulted in some very interesting discoveries. Progress made thus far are: (1) In pilot-line operations cans of tinless steel and low tin-bearing solder have been made at speeds comparable to that which tinplate cans are made; (2) Cans have been made in tin-free solders that give every promise of adaptability to universal use; (3) Tin-free cans in which a special plastic cement is used instead of solder for side seams are currently under test by several packers of oil and anti-freeze. Another important objective of this project is to find organic plate coatings made from materials available on this continent which will be equal or superior to those now made from imported ingredients.

Coatings For Protection of Steel in Water

By G. W. OXLEY
Standard Oil Development Co.

FOR MANY years protective coatings for steel in salt or fresh water have been given much attention for various industrial and marine requirements. In the petroleum industry there are many examples of steel surfaces, submerged in water, some of which are discussed in this paper. Experiences have shown that losses per year due to corrosion of underwater steel cost millions of dollars. In view of many early failures of such submerged coatings and the serious corrosion experienced, more complete protection has been desired either from coatings or other means. Ships, buoys, piling, pipe lines, tanks, condensers and other equipment in contact with water require adequate protection.

Some conditions intensified by marine organisms and other variables are so severe that coatings by themselves are not satisfactory for long protection. Substantial encasements are often required. Even these have to be supplemented by cathodic protection or some other material has to be substituted for mild steel. This paper is intended to discuss briefly the following:

(1) Variable Conditions in Underwater Services.
(2) Types of Coatings for Underwater Requirements.
(3) Test and Field Experiences for Various Services.

Some coatings for water services such as those for marine requirements have been discussed by various investigators. Many practices continue to be in an experimental stage as exemplified by extensive tests in the Gulf of Mexico, Lake Maracaibo, North Carolina, California, Florida and other locations. To prolong the life of equipment and conserve materials, there is a need for more case histories giving records of outstanding durability.

Variable Conditions

A WIDE variety of problems is involved for the different types of construction and equipment in contact with water. Water conditions vary in regard to alkalinity, acidity, salinity, aeration and dissolved oxygen. Impurities, marine organisms, bacteria, velocity, erosion, turbulence and abrasion affect durability of underwater coatings.

Future accessibility of surfaces for repainting must be considered. Alternately wet and dry conditions as in tidal locations increase the severity of conditions. Effect of chlorination and other treatments is also important. In case of cathodic protection, the submerged coatings must resist the alkalinity and maximum voltage. Elevated temperatures as in hot water tanks will accelerate failures of coatings.

For use under water, the soft and somewhat slow drying oil paints will in most cases absorb water and increase in volume. They are not satisfactory in resisting penetration of water or abrasion. As discussed by the N A C E Marine Paint subcommittee and others, underwater paints require special properties. Such properties or categories to be considered for submerged coatings include the following:

(1) Absorption of water in coating.
(2) Water permeability for various thicknesses of coating.
(3) Adhesion to various types of surface.
(4) Resistance to abrasion.
(5) Facility of application.
(6) Thickness of coating and number of coats.
(7) Drying characteristics.
(8) Resistance to weathering as in tidal locations.
(9) Resistance to alternate wetting and drying.
(10) Resistance to oil on water oil cargos or alternated with water ballast.
(11) Resistance to alkaline or acid waters.
(12) Rust inhibitive properties of primers.
(13) Anti-fouling for finishes in locations of marine organisms.
(14) Resistance to softening by prolonged immersion.

Types of Coatings

General: Coatings available for protection of steel surfaces in water include both organic and inorganic materials. The most common organic coatings for such services are asphalt, coal tar, phenolic, rubber and vinyl. The inorganic materials include cement and silicate base products and metallic such as galvanizing or metallized zinc.

Bituminous Coatings: There are many types of asphalt and coal tar coatings. They vary in regard to fillers, softening point, viscosity, type of application and properties in connection with water requirements. Some are used with various wrappings and shields. Experience has shown that both asphalt and coal tar have good waterproofing properties. A.P.I. 10 years tests of underground pipe coatings proved that bituminous coatings require ample thickness to eliminate pinholes and to prevent pitting in corrosive environments. These tests showed a wide range of conductances, pitting tendencies and

Presented before the Third Symposium of Paint and Varnish Chemistry sponsored by the College of Engineering of New York University held on Nov. 18, 1950.

other properties for cold applications (emulsions and cut backs) hot applied enamels, mastics, shielded coatings and reinforced coatings. In addition to a variety of coal tar products and petroleum asphalts, various natural asphalts such as gilsonite and wurtzilite used with different plasticizers or additives may be included in the bituminous classification. There are also available some rubberized asphalts and coal tars.

The hot applied bituminous enamels usually 1/16 in. thick or more are in general more impervious and more durable than the cut back or emulsified coatings which are much thinner. However, the hot enamels are more difficult to apply. Many bituminous coatings have shown shortcomings because of severe weather checking in case of atmospheric exposure in the tidal range or boot-topping areas.

Asphalts have shown excellent properties for various water services. They are used extensively for canal linings and river revetments and mats. They have proven to have good waterproofing properties and merit for various coating requirements. They have been used for tank bottoms, submarine pipe lines, inside water tanks and culverts and on other underwater surfaces.

Thixotropic solvent type coal tar coatings have been specified for underwater surfaces of piling and other requirements. Such products are sometimes used instead of hot coal tar enamel because of easier application. They require a suitable Alemite type pump and spray gun for application to adequate thickness, about 1/16 inch.

In Standard Oil Development (SOD) Co. tests, emulsified and cut back asphalts and coal tars, only a few thousandths of an inch thick, have shown failures in less than 60 days immersion in sea water. In these tests, the heavy bodied solvent type coal tar applied 1/16 in. thick, showed good protection both alone and over a phenolic base marine primer.

Bituminous materials have shown poor resistance to oil floating on the water. Coal tar is superior to asphalt in this respect but experiences have shown that it is not immune to solvent action by hydrocarbons.

Primers: Some years ago litharge (PbO) showed merit in hardening oil base primers for underwater service. In more recent years alkyd red lead primers and zinc chromate phenolic paints have shown merit. Some penetrating drying oil products having good wetting properties have shown advantages as first coaters getting well down into pits. For sandblasted surfaces to be coated with vinyl products, the polyvinyl butyral wash primer followed by anti-corrosive vinyl red lead or zinc chromate have improved adherence and durability of the vinyl coatings for underwater service.

Synthetic Resin Coatings: Air dried phenolic coatings have shown better protection than the old type soft drying oil base products on underwater surfaces of barges, tankers and other vessels. However, frequent renewal has been necessary. Aluminum leafing pigment has proven valuable in reducing water permeability of synthetic resin finishes. For surfaces which can be sandblasted, vinyl paints are replacing the air dried phenolic paints to some extent. They have shown merit in regard to water and oil resistance.

Inorganic Coatings: According to some reports from Australia, certain inorganic zinc silicate paints are claimed to have shown merit inside water tanks. As examples of other inorganic materials, gunite, cement mortar and concrete have shown merit for lining tanks or protecting pipe lines in water services.

Test and Field Experiences

Marine: As examples of practical applications, the oil industry has had extensive experiences with underwater coatings for various types of floating equipment. Various ship bottom paints, boot-topping for protection between high and low water and anti-fouling paints have been used. In the latter, some form of copper or mercury has been used as a toxic poison to prevent attachment of marine fouling. It is of interest to note that the Navy is now seeking a ship bottom protection which will last 15 years. Considerable attention has been given to this subject in various researches and in papers presented before the Society of Naval Architects and Marine Engineers as well as in various shipping publications.

Tests at Galveston have shown outstanding properties of the vinyl systems compared with the old type paints. Up to 14.5 months, excellent protection and very little fouling was shown by a combination of one coat of polyvinyl butyral wash primer, two coats of vinyl red lead anti-corrosive primer and two coats of vinyl anti-fouling. Several old type ship bottom primers and anti-fouling paints showed heavy barnacle accumulations and much inferior protection. At 23 months, this vinyl combination failed and was not as satisfactory as other reports on such paints have indicated. In boot-topping exposures, several conventional three coat phenolic combinations failed in less than five months. Under the same conditions a five coat vinyl system was free from rusting even after about 23 months. On converted LST equipment in the Gulf, some outstanding durability of vinyl coatings has been reported. Sandblasting is necessary and skilled labor must be used for proper application of such paints to realize satisfactory results. They are more expensive and require more coats than the old type conventional synthetic resin coatings. If removed from a ship's hull by scraping at an early age on river bottoms their higher cost may not be justified.

At Lake Maracaibo a few years ago, drilling barges were protected by a marine primer and a thick asphalt enamel applied hot. About every 9 to 12 months it was necessary to scrape, sandblast and recoat such surfaces. Vinyl coatings would be expected to be more durable but may not be practical for application particularly if there are no facilities for sandblasting or if penetrated by marine organisms.

For drilling and power barges in the Gulf of Mexico, underwater steel surfaces have been protected by a zinc chromate marine primer, a heavy coat of high melting point asphalt about ¼ to ½ in. thick, tar paper and creosoted wood banded in place. The timber serves as a barrier to protect the asphalt from gouging by small boats, drift wood, etc. According to reports, from 5 to 10 years service can be expected from such protection.

Anti-galvanic bituminous paints having good electrical insulating properties have been used at the stern of tankers instead of zincs for

galvanic protection.

In connection with interior cargo tank corrosion, much work has been done during the past 20 years. About 20 years ago, air dried phenolic base aluminum paint and a special lacquer, each with and without a phosphoric rustproofing treatment failed in a few months on a cargo tank bulkhead. Extensive SOD Co. laboratory tests have been conducted on coated steel panels subjected to test cycles of one week each in gasoline, sea water, and moist air in addition to a periodic hot water wash. Bituminous coatings cannot be used for such service as they are not resistant to the hydrocarbon cargo. More than 500 coating combinations have been tested with the object of finding a practical protection for the interior surfaces of clean service tankers.

In the SOD Co. laboratory tests, the following coatings have given good protection for 5 years or more: vinyl, heat hardened phenolic, cement and metallized aluminum over zinc 0.018 inch thick. Among the most promising coatings has been the vinyl type. However, in actual service early touching up of some failed surfaces has been necessary in less than one or two years. As previously emphasized, sandblasting is necessary in the use of such coatings. About seven coats are required and the cost is high. In these SOD Co. laboratory tank tests, heat hardened phenolic coatings have shown excellent protection for several years. However, no practical means has been devised for baking these coatings on large surfaces such as those inside cargo tanks. Such coatings were not satisfactory in a service test.

Underwater Surfaces of Steel Piling at Docks: The extensive use of structural steel for piling at the docks at Aruba, Venezuela and other locations has presented problems for the long time protection of the continuously submerged surfaces, tidal areas, splash zone and superstructures. For such underwater surfaces, protective coatings are supplemented by cathodic protection in the latest recommended practices. A Steel Piling Task Committee is assisting the Bureau of Yards and Docks in the development of improved coatings for steel exposed to salt water.

For some steel piling underwater surfaces, heavy coal tar coatings 1/16 in. or more in thickness have been applied. These are intended to give protection for five years or more and to reduce curent density requirements in the use of cathodic protection. In some locations such coatings may be penetrated by marine organisms.

For underwater surfaces of piling at Aruba and Venezuela, thixotropic solvent type coal tar coatings have been used with a minimum thickness of 1/16 in. Although no trouble was experienced in field and laboratory panel tests, experiences on piling showed early failures from these coal tar coatings over zinc chromate marine primers. Accordingly, it is advisable to use the solvent type coal tar coatings directly over the steel. In the use of such coatings, it is important that adequate thickness of 1/16 in. or more be applied. Some preliminary tests in connection with these piling projects showed early failures of the coal tar coatings if they were applied only a few thousandths of an inch thick.

At the Inco Harbor Island Experiment Station in North Carolina, tests of various coatings including vinyl, coal tar and metallizing are under way on steel piling. Metallized zinc with and without organic seal coats is being tested.

Offshore Drilling Structures: For the offshore drilling structures somewhat different techniques have been used. The underwater surfaces at Grand Isle in the Gulf were originally shop coated with a zinc chromate primer. As mentioned for dock piling it is expected that cathodic protection may be used to advantage for long time protection of such surfaces. In the tidal and splash zones, 8 layers of pipe coating materials were used for a multi-coat protection of the tubular supports. These included a coal tar primer, four coats of coal tar enamel and three intermediate wrappings of glass fiber and asbestos felt. Above this section up to the floor of the platform, another zone about 40 ft. long is protected by a heavy zinc dust, zinc oxide petrolatum rust prevented over three coats of phenolic base marine paints.

The zinc petrolatum coating has also been used in water compartments of barges, on guy wires and other surfaces where a non-drying coating is not objectionable. Heavy petrolatum coatings have also shown merit as rust preventives in sea water. In immersion tests at Kure Beach, N. C. they retarded marine organism accumulations and prevented pitting as crevice compounds under Bakelite washers.

Submarine Pipe Lines and Mooring Buoys: Submarine pipe lines at waterfronts, underwater flow lines and risers at Lake Maracaibo, and pipe lies at river crossings and swamps are subject to severe corrosion and require adequate protection.

At Lake Maracaibo, rapid coating of joints after welding in barge laying of pipe requires special attention. Rollers on which the coated pipe is handled should be padded and belt slings should be used instead of chains to prevent injury to coatings during placing operations. At Lake Maracaibo, teredo resistant barriers are required. At this location, asphalts, coal tars and other organic coatings with or without a toxic poison, have not been satisfactory for preventing the penetration of marine organisms such as the teredo healdi. In connection with this project, various asphalts and coal tars, some with toxics or teredo resistant barriers, are being tested at North Carolina, Texas and Venezuela. As in other experiences with bituminous coatings, the earlier tests have indicated the need for substantial protection.

Gunite, cement mortar and concrete have shown advantages in other locations for use as barriers over bituminous coatings on piping for resistance to marine organisms. Such material is also used instead of clamps, for weighting down pipe lines when they are being lowered under water.

Pipe lines at river crossings are given extra heavy bituminous coatings along with a concrete shield and in some cases other shielding material such as oak sheathing is used to prevent damage to the coating.

In Central America, some waterfront pipe lines are subject to alternately wet and dry conditions in the tidal range. Rapid curing asphalts only a few mils thick have not given good protection. Along with cathodic protection, pipe encasements with asphalt enamel in the annular space have been proposed for protection if the pipe line cannot be placed in a less corrosive location.

Steel mooring buoys require durable protection for both underwater and abovewater surfaces. Vinyl paints are being investigated for this purpose. In Australia, zinc silicate paints are reported to have given protection for two years on mooring buoys but thick accumulations of marine organisms were observed at the bottom.

Caissons in the vicinity of the flow stations at Lake Maracaibo require adequate interior protection. It is thought that corrosion at this location is due to some extent to anaerobic bacteria.

Miscellaneous Steel Surfaces: Cooling water is used so extensively at refineries and other industrial plants that protection inside steel pipe lines and equipment is important. As a failure of such piping may result in a costly shutdown of a refinery, long time protection is essential. AWWA cement mortar linings 3/16 in. or greater in thickness or coal tar enamel about 3/32 in. minimum thickness have each been used by various organizations for protection inside water lines. Fresh water supply lines must be similarly protected. In connection with higher pumping rates, some consideration has been given to the effect of higher velocities and turbulence on the cement and coal tar enamel linings.

Open type condenser boxes require protection against hot salt water or fresh water. Hot applied asphalts over various primers have given protection for less than a year. Reinforced gunite linings have lasted 15 years years or more. Based on latest experiences, cathodic protection appears to be the most economical for the long time protection of both the submerged coils and the underwater surfaces of the box. Some phenolic paints which are claimed to have little effect on heat transfer have been tried on condenser piping in hot salt water with various results.

Although some blistering and early peeling have been experienced, vinyl paints have given fair protection for a year in the salt water channels of shell and tube condensers. Heavy asphalt with a cement lining has given protection for a year or more. Synthetic rubber continues to be in excellent condition after 14 months on specimens in condenser channels.

For interior of water tanks relative merits and economies of zinc dust phenolic paints, inorganic zinc silicate paints, bituminous coatings, gunite, metallized zinc and cathodic protection should be evaluated for the service involved. Gunite has given good protection for as long as 15 years. Hot applied bituminous enamel is said to have given protection for a similar period. Phenolic base and other paints have given usually no more than 2 to 4 years service.

Gas holder lifts in contact with water seals have been automatically protected by a heavy black oil rust preventive as the lift rises. Various types of paints have been used on such surfaces such as an alkyd red lead primer followed by a phenolic base finish.

Questions

1. What are the experiences with the use of various groups of coaltar, petroleum asphalts, gilsonite and other bituminous coatings for the protection of steel surfaces under water?

Experiences have shown that hot applications of asphalt or coal tar, 3/32 inch to ½ inch or more in thickness are the most durable bituminous coatings for underwater service. For some purposes, they must be supplemented by substantial encasements or shields to resist penetration by marine organisms or to improve durability under other adverse conditions. Thixotropic bituminous coatings, 1/16 inch or greater in thickness, are the best of the cold applied but are less durable than the hot applied products. It is desirable to supplement the cold applied with cathodic protection for conditions such as submerged surfaces of piling in salt water. Emulsions and cut backs have shown early failures on underwater steel surfaces.

2. What is the influence of thickness and form of application of bituminous coatings?

Tests and experiences have shown that bituminous coatings, hot applied, are the most dependable of this type of coating. To reduce pitting to a minimum, bituminous coatings must be applied to a minimum thickness of 3/32 to ½ inch or more depending upon the materials and purpose for which used as well as supplementary protection. This bituminous coatings are not satisfactory for underwater surfaces.

3. What are the experiences in the use of inorganic coatings such as cement linings, galvanizing, metallized zinc, etc. in underwater protection of steel?

Cement linings have shown good results inside pipe lines in water services. Galvanizing has shown variable results. In some sea water tests, such zinc coatings have lost 0.001 inch per year or more. Other tests have shown less than one tenth of such corrosion rates for zinc. Metallized zinc requires applications at least 0.010 to 0.018 inch thick with chlorinated rubber or other seal coat for long time protection. Metallizing requires adequately sandblasted surfaces to prevent poor mechanical bond. The inherent porosity of such coatings must be overcome by adequate seal coats. Zinc silicate coatings properly heat cured to assure insolubility are claimed to have given good protection inside water tanks in Australia, but cement linings have been considered superior inside water lines.

4. What are the experiences with the use of rubber coatings or linings?

In tests, synthetic rubber, 3/16 inch thick has shown merit for protection of steel in the salt water channels of shell and tube exchangers for more than one year. Synthetic rubber hose has shown good durability for underwater requirements. Flame sprayed polymers have been used to some extent on outboard propeller shafts.

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The Role of The Vehicle In Paints For Submerged Surfaces

By A. C. ELM
The New Jersey Zinc Co. (of Pa.)

THE PURPOSE of painting under water structures is twofold: (1) the prevention of the attachment of marine growth generally referred to as fouling, (2) the prevention of the corrosion of the steel and other exposed metal surfaces. It is quite understandable that such complicated and in some respects mutually exclusive functions cannot be expected to be performed to an optimum degree by a single paint coating. A complex paint system is required to achieve these ends. The design of so-called antifouling coatings represents a field of highly specialized knowledge and is outside the scope of this discussion. Our only concern here is with the fundamental principles governing the behavior of the anticorrosive portion of the paint system, and their application to the solution of the practical technical problems confronting the paint engineer.

Paints as Barriers

CORROSION is an electrochemical process involving interaction between a metal surface and its environment. Therefore, corrosion may be prevented by the interposition between the metal surface and its environment of a film which is impermeable to any and all corrosive factors of the environment. A paint meeting this requirement does not exist and is not likely to be discovered. Hence, it is the task of the paint formulator to design a paint system which approaches this ideal as closely as possible without undue sacrifice of any of the many other requirements a paint must fulfill and to compensate for any deficiencies by the incorporation of auxiliary ingredients.

The degree to which this "barrier" effect can be achieved is a function of the continuous phase of the coating, that is the film matrix or vehicle. In order to fully utilize the inherent capabilities of a vehicle, a formulator should know the detailed mechanism by which various corrosive agents permeate or penetrate it. Fortunately, a considerable amount of work has been done on this subject so that today, there exists a reasonably good picture of this phenomen.

First of all, it has been definitely established that a perfectly continuous and pore-free film—and any metal protective coating worthy of its name should be pore-free—is not impermeable. The permeability of concern in this connection does not require the presence in the film of gross discontinuities or holes. This is a point which must be clearly understood, for without an adequate appreciation of this fact, the formulator will not be aware of the inherent limitations of a vehicle system. Perhaps, in order to avoid any possibility of misunderstanding, the term "film continuity" should be defined.

It is well known that the distribution of matter in space is not continuous. In fact, only a relatively small proportion of space is occupied by matter in the form of molecules. Without becoming involved in nucleonics and for the sake of simplicity, the molecules are here regarded as the smallest solid units. The space between the molecules is not occupied, but the force fields of adjacent or neighboring molecules touch and overlap in such a manner that no molecule could pass between them without coming under the influence of the force field of at least one of the neighboring molecules. A film in this state is continuous.

This concept receives considerable experimental support from an investigation of the porosity of paint films recently conducted by Harris and Wolock (1). Applying the Brunauer-Emmet method to the determination of the free surface area of paint films, these authors came to the conclusion that "there is no appreciable quantity of fine pores in the film large enough to allow physical transmission of water vapor" and that "even upon extracting the film with acetone, the area increased only slightly, indicating that the extraction merely roughened the surface but did not penetrate the film".

Presented at the Third Symposium on Paint and Varnish Chemistry sponsored by the College of Engineering of New York University held on Nov. 18, 1950.

Diffusion of Water

PERMEATION of moisture through films of this sort is by a mechanism akin to solution. The water molecules attach themselves to hydratable polar groups which are a part of the molecules making up the film substance, that is, they become dissolved in the film substance. They pass from one such polar group to others as a result of thermal motion until all or nearly all of the polar groups are "hydrated". Some of the water molecules attached to the polar groups on the low humidity side of the film will, as a result of thermal motion, leave the film by evaporation and are replaced by water molecules from the interior of the film by a process of diffusion. The whole process is governed by the laws of osmosis (2, 3).

The nature and concentration of the hydratable groups which are a part of the structure of the film matrix determine the rate of water absorption by and diffusion through the film. Among the polar groups which can serve as such hydration centers and hence provide the path along which water permeates the film are —OH, —OOH, etc. Such groups are usually present in film matrices formed by oxygen induced polymerization. Examples of such film formers are the drying oils and their modifications. It is clear then that films which are formed by reactions not involving oxygen are more impermeable to moisture than films formed as a result of autoxidation. That is one of the reasons why baked films usually possess greater moisture resistance than air-dried films, and that is why vinyl films have such outstanding water resistance.

Effect of Pigments

THE effect of pigments upon this vehicle property varies somewhat depending on the nature of the pigment and the type of the vehicle. However, there are a few general principles which may serve as reliable guides to the formulator. Pigment particles can increase the resistance of a matrix to water vapor permeability merely by forcing the water molecules to detour around them. In other words, pigment particles, when present in sufficient numbers, serve to increase the effective length of the path which the water molecules must travel from the high to the low humidity side of the coating and hence the time required for diffusion. It is readily understandable why platy pigments, which have a tendency to arange themselves in a position normal to the direction of water diffusion, are particulary effective in increasing moisture impedance. For a given quantity of pigment, leafing pigments increase the effective length of the vapor path by a much greater amount than do nodular pigments of otherwise identical characteristics.

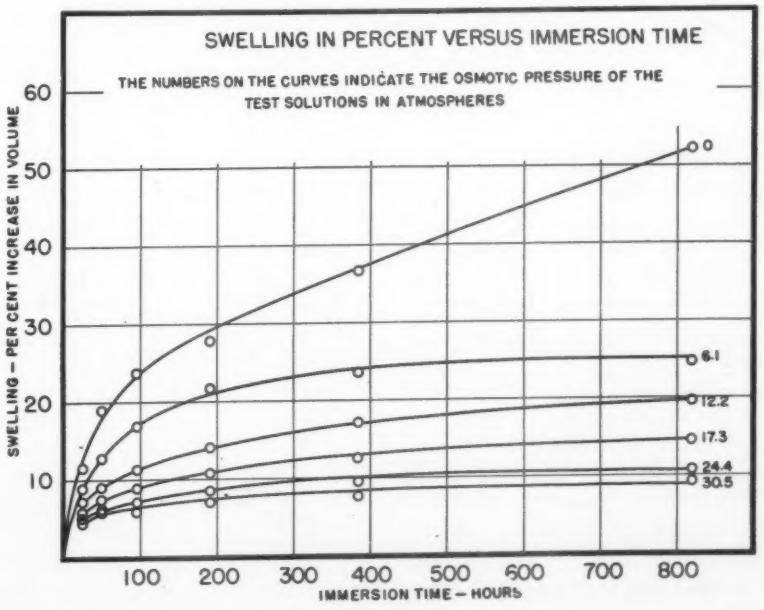
Of course, pigments can perform this function well only if the adhesion of the matrix to the pigment surface is strong enough. If this requirement is not fulfilled the pigment particles will assume the role of flaws and actually serve to decrease the effective length of the vapor path, hence increasing the rate of water diffusion. The strength of the bond between the vehicle and the pigment in turn is a function of the polarity of the matrix molecules and the nature of the pigment surface. Most common pigments, being hydrophilic in nature, readily attract such polar groups as —OH, —OOH, and —COOH. This does not only increase the bond strength but at the same time decreases the concentration of free hydratable groups in the matrix. Both of these phenomena combine to greatly decrease moisture permeability.

These general rules apply directly to the oxidizing type of vehicles based on drying oils, alkyds and phenolics. These vehicles are improved in moisture resistance to varying degrees by pigmentation (see Table 1). The improvement attainable by the incorporation of such hydrophilic pigments as silica is relatively slight, while the improvement resulting from pigmentation with such active pigments as zinc oxide and red lead is very considerable.

The presence of water soluble salts in the pigments exerts a surprisingly small influence upon the moisture permeability of a vehicle. This is understandable when it is remembered that the pigment particles are embedded in and completely surrounded by film matrix, and the influence on the overall phenomena of moisture permeability cannot be felt until a path for the water molecules has been established through the organic envelop.

It was stated before that the diffusion of water through a paint film is governed by the usual laws of osmosis. The rate of diffusion therefore is proportional to the osmotic pressure gradient across the paint film. Since, in a normal attached paint film, the osmotic pressure of the internal solution is relatively low, it is not surprising that water permeation into and through a paint film is negligible when the osmotic

Figure 1



Pigment	Relative Permeability
None	1.000
Silica	0.896
Chrome Yellow	0.695
Zinc Yellow	0.609
Iron Oxide	0.556
Zinc Oxide	0.428
Red Lead	0.419
ZTO Chromate	0.343

Table I—Effect of pigments on the moisture permeability of air-dried paint films.

pressure of the external solution is high enough (see Figure 1). In other words, water absorption of a paint film immersed in sea water is of little practical significance. This is strikingly demonstrated by a set of panels in our laboratory which were coated with linseed oil base paints pigmented with pigments ranging in water solubility from iron oxide to zinc yellow and which have remained free of blisters during an immersion in 3% salt solution, extending over a period of years; in fact, from 1944 to date.

Unfortunately, in actual practice, things are not quite so simple. There are complications. Corrosion is an electro-chemical process and the electrical potential gradient set up across the paint film exerts its influence upon the transport of water through the film. It has been possible to demonstrate that this water transport is toward the cathode and that the quantity of water that can be transported under the influence of ordinary corrosion currents is many times that pushed through the film by osmotic forces (4). As a result, the anticorrosive properties of a coating become more important than its water resistance in submarine service. In other words, it seems more important that the coating be an electrolytic barrier than a moisture barrier. The realization of the relationship between the electrolytic resistance of a coating and its protective value led the *Bakelite Laboratories* to the development of the Protectometer (5).

Diffusion of Electrolytes

IN order to be able to design coatings of high electrolytic resistance, the formulator must know something about the manner by which an electrolytic current flows through the paint film and what paint ingredients contribute to high electrolytic resistance and how. The laboratories of *The New Jersey Zinc Company* therefore set out to study the diffusion of electrolytes through organic membranes. The first phase of this investigation consisted of the development of a method for the determination of the instantaneous diffusion rates(6) and the second phase comprised the systematic application of this method to several paint systems. Some of the experimental results of this investigation are shown in Table 2. In order to facilitate comparison between the various effects under study, the experimental data shown are not given in absolute units but were reduced to relative values, setting the corresponding vehicle property equal to unity. The data in Table 2 then clearly show that the electrolytic resistance of a paint system is largely dependent on the resistance of this system to the diffusion of ions and does not seem to be materially affected by variations in its water permeability. In fact, the agreement between the relative resistance to the diffusion of sodium chloride and the relative resistance to the passage of the electrolytic current is so good that one is tempted to conclude that salt diffusion is the property which controls the electrolytic resistance of a paint system.

In the course of this work evidence was developed which indicates that the mechanism by which electrolytes diffuse through organic membranes is, in many respects, analogous to the mechanism by which water permeates a paint film. The film matrix must contain certain polar groups before ions can be imbibed by it and diffuse through it. On the basis of experience with ion exchange resins it is rather generally agreed that cation exchange is readily accomplished if the exchange medium contains a sufficient concentration of acidic group such as —COOH, —OOH, phenolic —OH and —SO_3H while an ion exchange demands the presence of basic groups such as —NH_2(7). Phenolic resins are representative of the former class while the latter class is typified by urea and melamine type resins. It seems logical to reason that acidic resins like the phenolics might permit the ready permeation of cations while urea or melamine resins would allow the diffusion of anions. It is also not too difficult to understand why some pigments might interfere with such ion diffusion by reacting with the proper polar groups and by putting them out of commission so to speak. There is the possibility that the application of the knowledge recently gathered on the mechanism by which ion exchange resins function to the formulation of submarine coatings might prove to be rather fruitful.

Adhesion

IT IS obvious that any paint system can perform these protective functions only if it establishes intimate contact with the metal surface and continues to adhere to it strongly throughout its useful life. Without adequate adhesion, a paint system cannot do its duty. There is no doubt that it is the responsibility of the vehicle to provide this adhesion.

The forces which hold a paint coating in place are twofold:

(*Turn to page 36*)

Table II—Relationship between the diffusion of water and sodium chloride through alkyd paint films and their electrolytic resistance.

Pigment	Relative Water Vapor Impedance*	Relative Sodium Chloride Impedance*	Relative Electrolytic Resistance
None	1	1	1
Chrome Yellow	1.1	3.4	2.5
Zinc Yellow	1.3	0.016	0.02
ZTO Chromate	2.0	12.5	14.5
Red Lead	1.7	0.59	0.75
Zinc Oxide	...	2.0	1.6
Iron Oxide	...	0.03	0.04
Aluminum	...	25.0	28.0
Silica	1.06	0.007	0.006

* Reciprocal of relative rate of diffusion.

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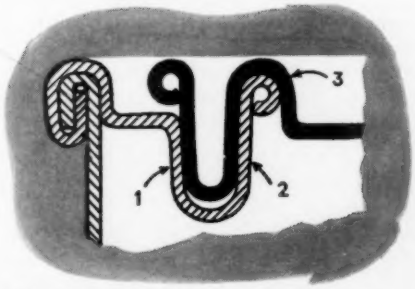

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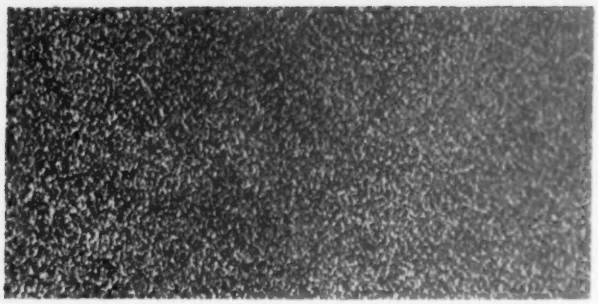


Figure 2

Importance of SURFACE PREPARATION For the Protection of Metals

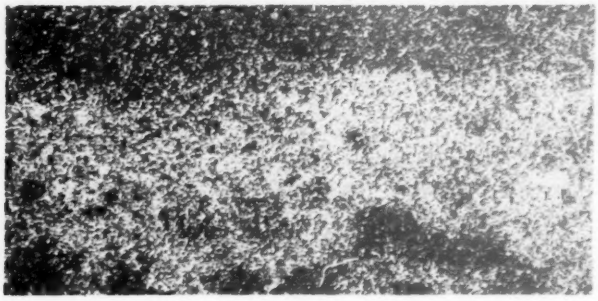


Figure 3

By A. J. LIEBMAN
Dravo Corp.

THE CONDITION of a metal surface constitutes any variance between a good and a bad foundation for paint; consequently, the surface preparation of a metal is partially responsible for the ultimate protection offered by a coating to the metal.

Paint is held on a metal by:

1. Its molecular attraction to the metal (called adhesion), or
2. By a mechanical anchor which is specifically developed on the metal by either an abrasive or a chemical method (called bonding).

In order to discuss surface preparation for painting, one must visualize what constitutes the most ideal surface condition for a good paint anchor. For general work, this anchor would constitute a metal surface free of soil and chemical products. It would be a smooth surface, free of scale or oxidation products. It would also possess a mechanical surface anchor with a depth of approximately one-third that of the coating thickness that must be applied, by approximately the same distance between anchor peaks. Minute anchor crevices would surround the individual anchor peaks and the peak would not come to a point, but it would mushroom slightly to close a small percentage of the opening between the various peaks. This would be the ideal combination mechanical bond, reinforced by perfect molecular attraction. (See Fig. 1.)

For practical and economical reasons, the exact condition of this theoretical surface anchor cannot be obtained. However, we can make an attempt to come as close to this condition as the service and anticipated life of the product compels us, bearing always in mind the characteristic of the coating that must be applied.

Function of Molecular Forces

MOLECULAR forces for paint adhesion are inherent in all metals. Depending on the permanent wetting and adhesion characteristics of a coating, one must expose to the coating a minimum area of clean

Presented at the Third Symposium on Paint and Varnish Chemistry sponsored by the College of Engineering of New York University held on Nov. 18, 1950.

Fig. 2. Uniform sand grain will produce uniform surface anchor. This steel plate was blasted with hard 30-50 grit sand and represents either the white or commercial blast finish pattern.

Fig. 3. Brush-off sandblasting produced at 650 to 1,000 sq. ft. per hour. The light areas are scale free; whereas dark areas are mill-scaled steel which received sufficient sand anchor pattern.

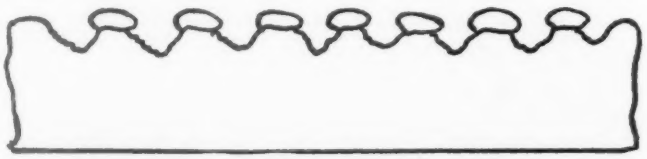


Figure 1. A clean anchor as shown would provide a perfect mechanical bond as well as excellent molecular attraction (adhesion). For a 6 mil paint film, the anchor depth should not exceed 2 mil. This anchor is theoretical and is not obtainable in practical application.

metal. A coating with very good permanent wetting and adhesion characteristics requires a much smaller area than a coating with poor characteristics.

The best adhesion is given by a product which has greater adhesive attraction for the adherent surface than its cohesive attraction within itself. The physical factors which affect the strength of bond between an adhesive and an adherent, involve:

1. The closeness of contact.
2. The surface area.
3. The stress conditions.

The molecules of the two materials must be brought into close enough contact for the molecular forces to become operative. Metal is a relatively homogeneous assembly; however, at the surface, it exposes to the paint a very dense pattern of crevices. Because of its freely flowing electrons, a metal has minor image forces induced at its surfaces which are equal and opposite to the polar forces of an adhesive used on it. Therefore, insofar as polar properties are concerned, an adhesive would have as great an affinity for a metal as it would have for a material with a polarity comparable to its own.

Mechanical anchors are produced with several processes.

1. Chemial etching.
2. Electro-chemical etching.
3. Anchor produced by metal shot blast.
4. Anchor produced by metal grit blast.
5. Anchor produced by a synthetic grit blast.
6. Anchor produced by a sand blast.
7. Anchor produced by a chemical pretreatment.
8. Anchor produced by grinding.
9. Anchor produced by uniform surface corrosion.
10. Roller roughing at the mill.

There are two further classifications of end conditions that must be borne in mind.

1. End condition of a steel surface that is covered with mill scale and which must be cleaned with any blasting process.
2. End condition produced by a chemical pretreatment.

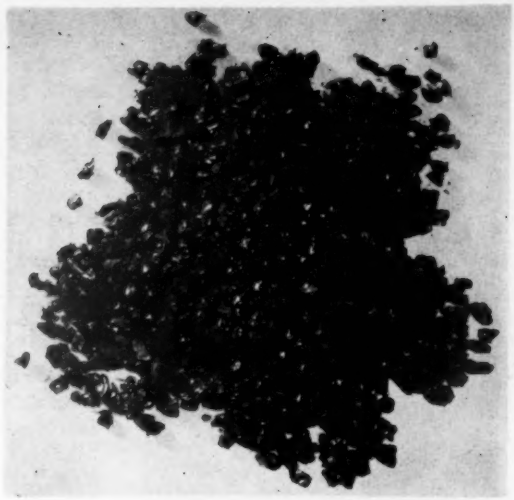


Figure 4. Closeup of a synthetic silica free blasting abrastive. Please note sharp edges for speedier cutting.

Blasting Process

DEPENDING on service requirements, three different end conditions can be produced with any blasting process when mill scale must be removed from steel.

1. White Steel Surface Finish, which covers the complete removal of all corrosion products, all mill scale, and the dark grey mill scale binder, thus exposing the white metal for a good paint connection. On flat work of new scale, single nozzle blasting will produce from 75 to 140 sq. ft. per nozzle hour. (5/16″ nozzle at 100 lbs. pressure. It is suggested that nozzle distance from steel surface be 12″ to 18″). (See Fig. 2).

2. Commercial Surface Finish, which includes the complete removal of all corrosive products, as well as all tight and loose mill scale. It does not include the removal of the dark grey binder. A commercial blasting job will look rather streaky; however, it does produce a very excellent surface anchor for a good paint connection. On flat work of new steel preparation speed is 240 to 450 sq. ft. per nozzle hour. (5/16″ nozzle at 100 lbs. pressure. It is suggested that nozzle distance from the steel be 18″ to 24″.)

3. Brush-off Surface Finish, which includes the complete removal of all corrosion products, as well as all of the loose mill scale. *It does not include the complete removal of the tight mill scale.* However, the blast material does produce on the tight mill scale an anchor pattern, which is found fully suitable for a good coating connection. On flat work of new steel, preparation speed with 30 to 50 grit abrasive equals 650 to 1,000 sq. ft. per nozzle hour. (5/16″ nozzle at 100 lbs. pressure. It is suggested that nozzle distance from the steel surface be 20″ to 30″.) Before applying coating, surface should be solvent cleaned. (See Fig. 3).

The advantages of these three specific conditions can be seen when one compares surface preparation costs with surface and service conditions. For instance, a product that must perform a lifetime of service without subjection to impact or high vibration stresses, will hold a coating as effectively on a surface that was prepared with the brush-off method, as the one that received a white steel preparation. However, if impact and other surface forces will produce undue stresses between metal and coating, or if a coating must be used in underwater service,

With the ever increasing number of new paints that are being used by the industry, we require a broader knowledge of precise end conditions that must be met by the metal interface in order to produce near permanent adhesion or mechanical bonding of the coating to the metal.

The theory of adherance and bonding and the practical attainment of same go hand-in-hand, and must be understood by anyone who is interested in obtaining the greatest return out of his investment in paint.

It is my intention to highlight the present science of metal surface preparation for coatings to bring benefit to the man in the laboratory, as well as the man who must do the work for industry.

Figure 5. Blasting sand of 30-50 grit size will produce a very uniform surface anchor for good paint bonding and adhesion to steel.

nothing less than a commercial surface preparation should be selected. In some cases, the white steel surface will be necessary.

The aforesaid surface conditions can be held within understandable tolerances. Complete knowledge of these conditions helps to develop economical end costs in practice.

Chemical Pretreatments

1. Surface Cleaning with solvents, alkalies, and emulsions for the purpose of removing all soil, grease, and oil, etc. This treatment does not react with the metal and must be painted immediately or followed by either the *surface reaction* or *surface conversion* treatment. The complete exposure of clean metal to the atmosphere will cause a nearly instantaneous minute oxide film formation. This is often considered a reaction; however, it is not caused by the solvent, but is rather the normal change found on any clean steel surface when exposed to the atmosphere.

2. Surface Reaction with dilute phosphoric acids and alcohol, produces a slight etch on the metal. Since the reaction is only slight, paint should be applied within one hour after metal so treated has dried.

3. Surface Conversion with chemical solutions change the iron and steel surface to a non-metallic coating which can be measured. This system can be recommended only where the product can be handled in and out of spray or immersion tanks, and solution temperatures can be held between 70° to 210° F. These treatments provide the most complete steel surface preparation in commercial use today.

Depending on the end use of the product, the general line of surface inhibitors used on structural outdoor applications, fall into Category 2.

Most inhibitors form soluble and insoluble salts which remain on the surface. These salts must be removed by either fresh water washing or with a soft rag or brush, followed by an air blow-off. Scratching of an inhibited surface must be prevented, since it will expose the underlying metal to the atmosphere.

Inhibitors are helpful and essential to neutralize weld flux scum deposits either directly on or adjacent to the weld. Many a paint failure on a weld seam can be prevented through the use of a good inhibitor treatment. Weld fluxes are alkaline, and inhibitors are acid neutralizers.

4. Permanent Metal Activation with a vinyl metal conditioner is produced by spraying or brushing the formulation on the metal. It inhibits the metal, gives temporary protection against corrosion, enhances adhesion of subsequent coatings to metal, and prevents corrosion creepage in case of damage.

Economical selection of each of the surface anchors for a specific service requires knowledge of peculiarities of the process which establishes a mechanical anchor.

Etching

COMMON chemical or electrochemical etching is produced with one of several acids in concentration ranging from 2% to 30%. Extreme care must be exercised in cleaning of the metal before and after etching. Solution agitation is another important phase of this operation to prevent smut deposit damage to paint which must be applied to the part. Soiled or oily metal must be cleaned with an alkali emulsion or solvent bath, in order to produce a uniform etch on the surface with the acid treatment.

The anchor produced by a controlled etching process is of a very fine variety. It has depth as well as a slight interlocking shape.

The abrasive anchor produced by metal shot, metal grit, or any other abrasive material, results from a high velocity impact of the abrasive as it is discharged from an average blast nozzle or wheel-type blasting machine. Abrasives cannot be selected at random, but must be a part of a plan that bears in mind:

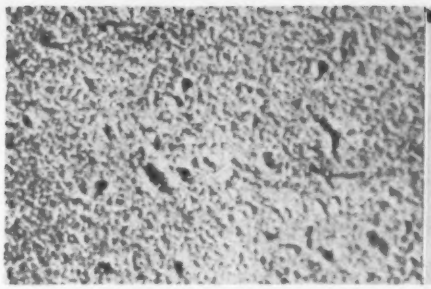
1. The equipment that is available.
2. The location where the surfaces must be cleaned (indoor or outdoor).
3. The type and thickness of coating that must be applied.
4. The shape of the structure that must be prepared.

Steel shot or grit are generally used for blasting in areas where the atmospheric moisture is low enough to prevent corrosive attack on the metallic abrasive. Shot removes mill scale and corrosion products, and also produces a peening or tightening of the metal at the paint interface. Unless the shot cracks and the sharp edges of the broken particles dig into the metal for a sharp anchor, a shot anchor is rather flat. The selection of a coating must have better adhesion characteristics than with sharper abrasives.

Steel grit of the angular shape is used extensively where a sharp anchor is desired. The major difference in the use of shot and grit lies in the end shape of the anchor. The most favorable metal blast anchor is de-

Fig. 6. Blasting sand of excessive size variation produce unsatisfactory surface anchor. The coarse particles leave deep impressions on the surface. Finer particles disintegrate more quickly in this mix, thus increasing the breakdown rate and the hazard of silicosis.

Figure 7



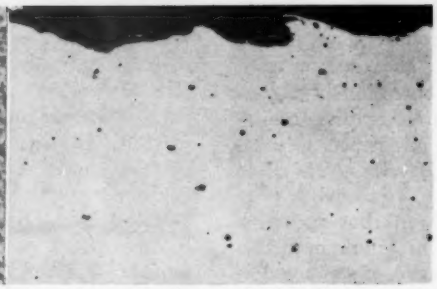


Figure 8

Fig. 7. This unsatisfactory surface anchor was produced by a nonuniform sand. Note the many pockets which are the result of oversize sand particles. The high points around these pockets cannot hold the paint. Low areas will allow dust and chemicals to settle causing paint failures. Fig. 8. Section of a sand blasted metal surface (new steel) 200× enlarged. High breakdown rate of sand causes a secondary line of attack as indicated by undercut anchors for good bonding.

veloped by a combination of shot and grit. The steel grit develops a distinct sharp anchor and the shot helps to flatten some of the peaks. The dual effect creates an interlock for the paint, which is more desirable than the anchor produced by either blast material when used by itself. Metallic abrasives can be recirculated many times. Due to their low breakdown rate, they are found very economical on large scale operations.

Synthetic blast materials produce an anchor similar to steel grit. Due to their composition, synthetic abrasives will cut fast. Synthetic grit is more brittle than metal; consequently, breakdown losses are considerably higher than with metal shot or grit. (See Fig. 4.)

Sand generally is well accepted by the industry for general all around blast cleaning. In order to increase production to a maximum and reduce dust to a minimum, the selection of a clean and hard sand becomes extremely important. (See Fig. 5.)

Tests have shown that sand breakdown rates can vary from 7½% to 40% per pass. The anchor produced by the different sands will vary with the basic shape of the sand particles. (See Figures 6 and 7.)

The scale, rust, and other products removed from steel will produce an uncontrollable quantity of dust and waste. If it is at all possible, good blast sand should be reclaimed, rescreened, and reused until a maximum surface breakdown makes its further reclaiming uneconomical.

Fine dust from sand, corrosion, and mill scale, must be removed from the metal since its presence reduces the intended wetting effects of a coating. This becomes more important with the faster drying synthetic and plastic paints, which are applied with a gun. Dust can be worked into paint more readily with a paint brush than with a spray gun.

Selection of Abrasives

IF all surfaces were perfectly smooth, the selection of a blast abrasive for surface preparation could be based on its cutting efficiency. Since a major portion of surface cleaning must be done on badly corroded metal of considerable variation in shape, the end results obtained with the abrasive vary with the impact and breakdown characteristic of the individual abrasive.

Metal abrasives have a very low breakdown rate. Their impact force is very high. Very little abrasion is affected with metal abrasive in more than one line of travel. Its main work is done during its initial contact with the metal. The breakdown rate of sand and various synthetic abrasives is much higher than that of metal abrasives. In other words, more abrasive particles return from the metal than are initially directed to it. The smaller particles which break away from the main grain of sand or synthetic, establish a secondary angle of attack on the metal. This secondary motion is extremely helpful when rusted cavities must be cleaned up. The large grain does the work in direct line with the blast stream and the small particles which break away become active at various angles to the main blast stream, depending on the mass of blast material and the mean angle of attack. (See Fig. 8.)

In this manner, the higher breakdown losses with sand and synthetics are actually doing a dual job. The side walls of a cavity are readily cleaned with a lesser variance of nozzle position. It must be borne in mind that this secondary impact is caused only by the fine particles which break away from the full size grain. Abrasives with a high breakdown rate must be consequently rescreened; otherwise, they become polluted with fine abrasives, as well as corrosion and scale dust, all of which tends to cushion the performance effect of a well-screened abrasive.

A very minute side anchor is also produced on the major blast anchor peaks with this fine abrasive, which breaks away during the initial impact with the metal.

On jobs where a particular fineness of finish is important, the dark colored synthetic abrasives offer distinct color advantages to the finished surface. Sand will discolor a tight mill scale to a point where it actually looks like white metal. With a dark colored synthetic abrasive, the scale will remain dark in color until it is completely removed, including all of the grey scale to metal binder.

The chemical pretreatment of steel can also be considered as a surface anchor since it establishes a very fine chemical etch on the metal, following the crevice lines established by the structure of the metal. This etch and consequent non-reactive coating, is often helpful if it is used following the various blast cleaning operations. Each major peak and valley in the blast pattern is reinforced with this minute chemical etch, which helps to create a large number of anchor stations for the paint. These additional anchor stations and the deposits of a non-reactive chemical coating prevent corrosion creepage whenever mechanical impact cuts the main film of the paint to the metal.

Grinding produces a scratch and steel sliver anchor. This anchor is

very effective; however, it is less economical to produce than are the abrasive blast or chemical anchors.

The uniform corrosion of a steel surface that was either prepared by various cleaning or surface preparation processes, develops a surface anchor for paint. The anchor is of a similar nature to that produced with chemical inhibitors or treatments. The atmospheric effect does not necessarily have to be extensive. Two to six days exposure are sufficient to produce a measureable anchor, according to work done by *Dr. J. C. Hudson.* Paint performance on these corrosive anchors has been found more favorable than on plain non-rusted and untreated steel.[2]

1. Painting over intact mill scale gave poor results.

2. The poor performance on freshly descaled surfaces was improved to a large extent, either by the use of phosphoric acid washes, or by the exposure of the pickled surface to the weather for six days before painting.

For example, the percentage of intact paint left on surfaces pickled in hydrochloric acid and painted with a linseed oil-red lead-red oxide paint increased from 8 to 79 rating, by the use of chromic-phosphoric acid wash. (Per *Dr. J. C. Hudson's* report in the July 1950 issue of the *Journal of Iron & Steel Institute.*)

Roller roughing of steel at the mill is produced by a matte finish on the rolls. Roll pressure against the cold rolled and other scale-free steel forms on the surface the same specific anchor pattern that is designed and worked into the roll by either a chemical or mechanical process.

Wire brushing, scraping, and flame cleaning of steel, are also classified as surface preparation processes. They do remove loose deposits from the metal, but leave no physical markings which can be classified as either a chemical or mechanical anchor. In most cases, the use of either of these three processes must be preceded or followed by a solvent cleaning operation. Many of the molecular crevices are being filled with soil, especially during a power-brushing operation, thus reducing the adhesion of paint to metal proportionally.

As surface preparation work becomes more of a science, the men working with various phases of metal protection must get better acquainted with all known surface preparation processes. They must also know the minimum surface preparation requirements of each specific coating for the environment under which it must serve.

Once we start using and assembling our present known surface and coating values, we can come up with some fairly dependable specifications, at least within acceptable limits for industrial use. There are many surface conditions to which neither of the aforesaid surface preparations can be applied. There are coatings available which will offer protection to a structure without an extensive and costly surface preparation job. However, when coatings are applied over mediocre surface foundations, the total economics of the project and past experience must dictate its selection. It should never be done by a guess, purely hoping for good end results.

References

1. "Adhesives and Adhesion" by R. C. Rinker and G. M. Kline—November 1945 issue of Modern Plastics.
"Fundamentals of Adhesion" by G. M. Kline and F. W. Reinhart—September 1950 issue of Mechanical Engineering.
2. Dr. J. C. Hudson—July 1950—Journal of Iron & Steel Institute.

Questions for Discussion

1. What surface conditions are desirable and what must be avoided for underwater service, and how are these influenced by the type of coating to be used?

Actually, we have three questions:

(a) The white steel finish, which is free of loose and tight mill scale corrosion products, as well as the grey mill scale binder, will assure the coating of the best and most desirable surface condition. For many reasons, the cost to produce this surface may be too high, or lack of time does not permit the vessel to be held long enough to produce this surface condition. The commercial finish will satisfy the needs in most cases. Here, we only remove the loose and tight mill scale, as well as all corrosion products, but we are not concerned with the grey mill scale binder.

(b) Mill scale and corrosion products must be avoided. Rough welds, sharp demarcations, cavities caused by corrosion, or non-uniform blasting abrasives, should be reduced to produce a minimum of local resistance or turbulence.

(c) The wetting and adherence characteristics as well as the film thickness and toughness of a coating will determine to a large extent how much particular attention must be paid to any of the aforesaid conditions. For instance, a coating with good wetting and adhesive qualities will overcome minor scale and dust, yet it will be more readily attacked by water turbulences. A tougher coating film will resist turbulent abrasion fairly well but has usually poor wetting and adhesion characteristics for performance on a poorly cleaned surface.

2. In the reconditioning of equipment, can the initial cleaning up of the surface be combined with surface preparation for recoating?

That all depends on what must be removed and what type of coating must be applied to the equipment.

(a) If paint and corrosion products must be removed from the surface by sandblasting, there is no doubt that the entire cleaning and surface preparation work can be combined into one operation.

(b) If a considerable amount of chemical service soil, grease or oil is present, it is always best to remove such undesirable products before the surface is actually prepared by blasting or chemical treatment.

(c) The surface condition prerequisite for the specific coating that must be applied is another factor that should not be overlooked. One coating may be compatible with a soil film which cannot be tolerated even as minute as an invisible trace under another type of coating.

3. What is the minimum thickness of coatings over certain profiles of the surface and how can the surface preparation be conducted so as to allow sucessful coating thickness?

The minimum thickness of a coating should be three times that of the anchor profile. The selection of a uniform grain blast cleaning abrasive will help to produce a uniform sur-

(Turn to page 37)

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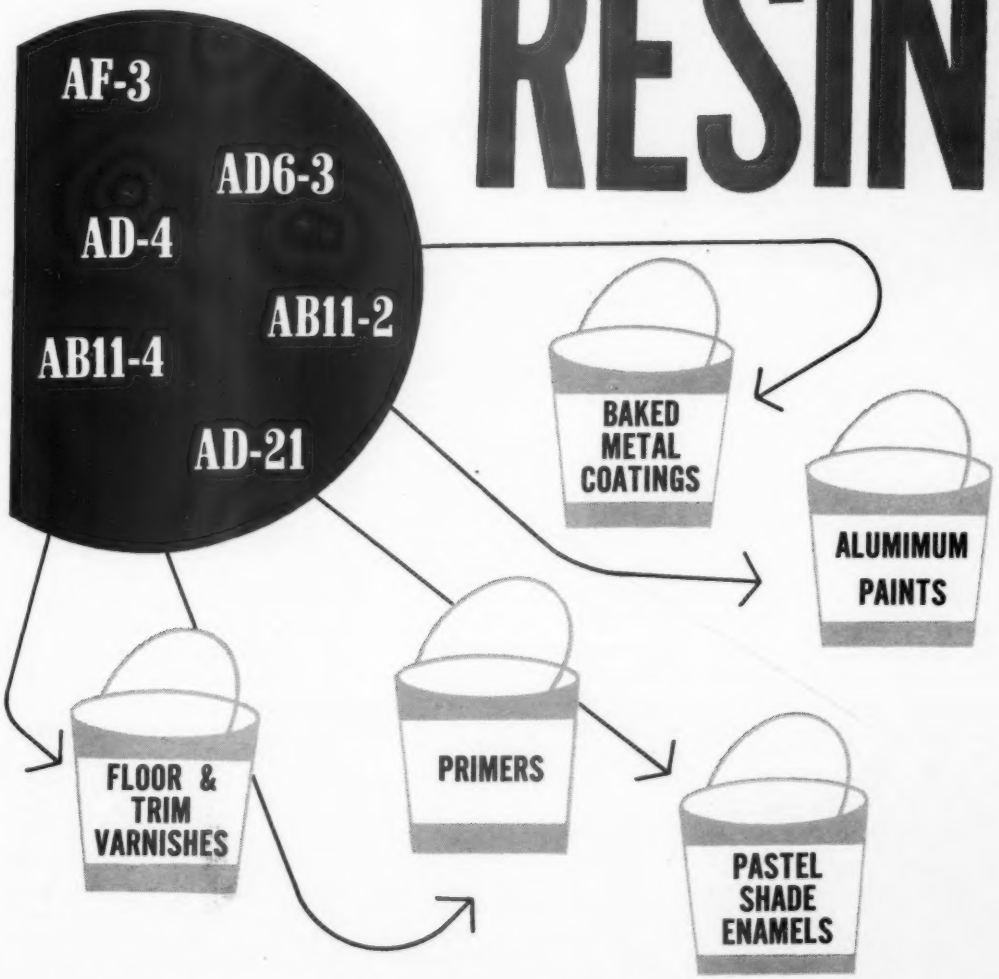

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Protective Coating for Submersible Type Transformers and Network Protectors

By V. A. VEIT
Consolidated Edison Co. of New York, Inc.

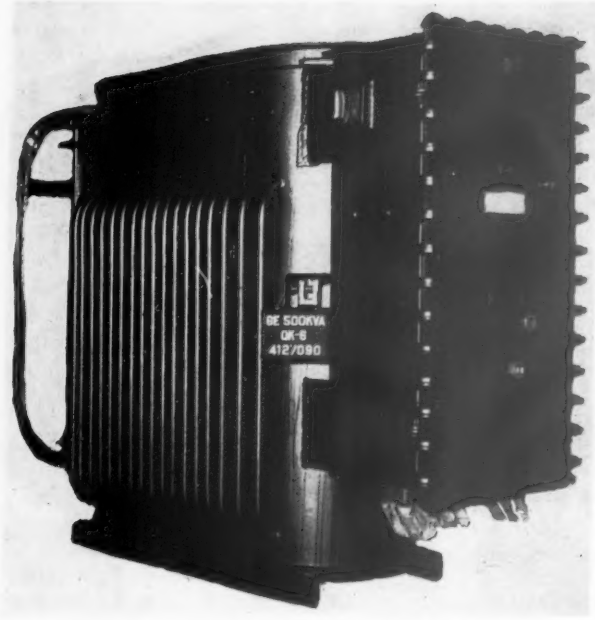


Figure 1. Typical submersible type network units

THE PROTECTIVE coating of the external surfaces of submersible type transformers and network protectors, which are installed in manholes below the street grade on the Consolidated Edison System, is a problem of increasing concern. During the past few years, due to the extensive use of salt for removal of ice and snow from the City streets, there has been a considerable increase in the number of protective paint coating failures after this apparatus had been in service for only one or two years. This period of time is not at all comparable with the service life of other components of the apparatus, which is in the order of 30 years or more. For this reason and others which follow, there is a very definite need of a much more durable protective coating for this particular type of apparatus.

The removal of this apparatus from the manholes is in most instances governed by failure of the protective coating and consequent corrosion rather than by deterioration of other parts of the apparatus. Limited working space in a large percentage of the manholes necessitates removal of the apparatus for repainting. This is a costly procedure and usually involves extensive work on congested streets, which is avoided whenever practicable. The apparatus is inspected periodically and it is the practice to remove it from the manholes before the corrosion has become excessive. This is due primarily to avoid the possibility of hazardous electrical failures and to prevent such severe corrosion that extensive replacement of corroded parts becomes necessary.

There are approximately 4,500 transformer installations in manholes on the Consolidated Edison System and network protectors are included in about 3,900 of these installations. About 3,700 installations are of the type which have insufficient working space for repainting the apparatus in the manholes and these are being increased at the rate of about 250 per year.

Apparatus & Installation

FIGURE 1 shows two typical submersible type network units of the same electrical capacity. Each unit consists of a transformer with an attached network protector. The smaller unit is of more recent design. All of the other network units on the Consolidated Edison system are of similar designs except that some of the transformer tanks have as many as four rows of cooling tubes.

The transformer tanks are made of steel and they contain high and low voltage insulated copper windings which are immersed in oil. The oil circulates through the windings and serves the dual purpose of cooling and insulating the windings. It is imperative that these tanks be maintained pressure tight to prevent the loss of oil and entrance of water, either of which would be detrimental to the operation of the transformers.

The network protector housings

Presented at the Third Annual Symposium on Varnish and Paint Chemistry sponsored by the College of Engineering of New York University on November 18, 1950.

are also made of steel and contain automatic low voltage air circuit breakers, relays and associated wiring which constitute the network protector. These housings must also be maintained pressure tight to prevent the entrance of water to assure proper operation of the network protectors.

Most of the older transformer tanks and network protector housings are made of ordinary mild steel and those of more recent design are made of copper bearing steel. The thickness of the steel varies on units of different design and on various parts of the same unit from 1/16″ to 1/2″. Transformer tanks and network protector housings of more recent design have a minimum steel thickness of 5/16″ and 1/4″ respectively.

Figure 2 shows a typical ventilating type removable grating which constitutes the entire roof of the manhole. It may be noted that this particular grating is located on a down-grade and close to the curb where it is exposed to drainage from the street.

Figure 3 shows the installation of one of the smaller network units in a manhole from which the full grating roof has been removed. Installations of this type have but a few inches of clearance between three sides of the network units and the manhole walls and about three feet of working space in front of the network protectors.

Figure 4 shows two typical ventilating type removable gratings as used on manholes in which the larger network units are installed. One grating is located at each end of the manhole above a working space of about three feet between the network unit and the manhole wall. There are only a few inches clearance between the two sides of the network unit and the manhole walls in installations of this type.

TABLE I

Analyses of tide water show approximately 20,700 parts per million of dissolved salts, of which the predominant salt is the chloride. In manholes containing snow-removal salts, washed in from the street, salt contents as high as 44,500 parts per million have been measured.

	Parts per Million	
	Sample 1	**Sample 2**
Total dissolved salts	1058	11,933
Organic Matter	59	44
Silicon Dioxide SiO_2	4	13
Iron & Alum. Oxides, $Fe_2Al_2O_6$	4	8
Calcium Oxide CaO	29	474
Magnesium Oxide MgO	59	118
Sulphur trioxide SO_3	63	654
Alkalies as Sodium Na_2	260	2,993
Chlorine Cl_2	476	5,990
Carbonates CO_3	None	None
Bicarbonates HCO_3	88	478
Phosphates PO_4	None	None
pH	7.5	7.7

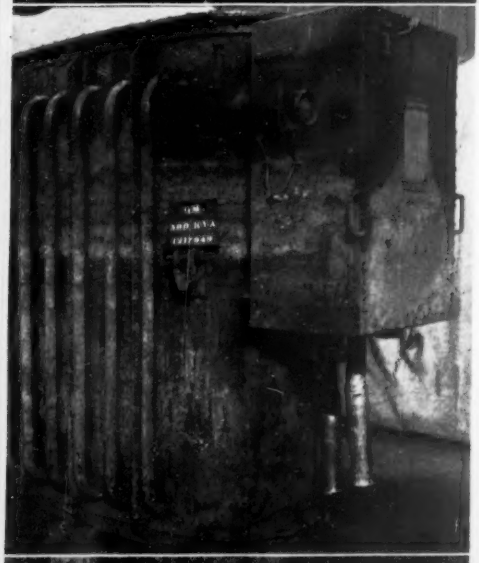
Description of Manholes

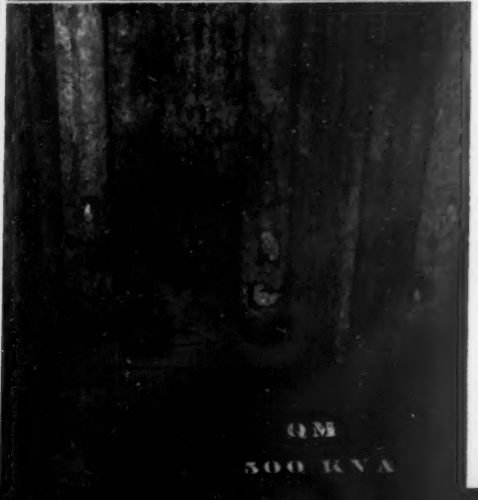
MOST of the manholes are made of steel reinforced concrete and a few of the older ones are made of brick. Although the manholes vary somewhat in size, only the older ones equipped with apparatus of small capacity, provide adequate space for either complete inspection or repainting of transformer tanks and network protector housings. Each manhole has at least one ventilating type removable grating at the street surface and, where practicable, the manholes are provided with facilities for drainage to storm sewers. An effort is made to locate new manholes where they may be provided with drainage facilities and where they will be less susceptible to drainage from the street. Due to congested conditions below the city streets, however, a large number of manholes are built

Figure 2. Ventilating type removable grating. This constitutes entire roof of the manhole.

Figure 3. This photo shows an installation of one of the smaller network units in a manhole.

Figure 4. Ventilating type removable gratings used on manholes for the larger network units.





close to the curbs where they take an appreciable portion of the street drainage.

When in service the transformer tanks and network protector housings normally attain a temperature of between 50 and 75° C. for an extended period daily, and occasionally may attain a temperature as hig has 100° C. They are also subjected to immersion by subsurface water as well as by street drainage having the accelerating corrosion factors of sewage, oil, salt, mud and debris. Because of the extensive use of salt for removal of ice and snow from City streets and, since salt water from nearby rivers is used to flush the streets during water shortages, a considerable quantity of salt drains into the manholes. The manholes and apparatus are cleaned with fresh water at the time periodic inspections of the apparatus are made. However, the water, mud and debris accumulates in the manholes and remains in contact with at least the lower portions of the transformer tanks for long periods of time. About 25% of the manholes have 6″ or more of water in them at all times and approximately 10% have more than 3′ of water most of the time. Some of the transformers are also exposed to the weather because they are installed in manholes which have large ventilating type gratings that constitute the entire roofs of the manholes. Furthermore, these particular transformers have operating accessories on the covers of the tanks and the maintenance personnel stand on these covers while performing their work.

Manhole waters vary widely in respect to chemical content. Analyses of water from two manholes are given in Table I.

Top to Bottom

Figure 5. Corroded condition of typical network unit after ten and one-half yrs. service.

Figure 6. Photo shows heavy corrosion on lower portion on end of transformer tank.

Figure 7. Corroded condition of another network unit after eighteen years of service.

Figure 8. Photo shows in more detail the corrosion on lower portion of transformer tank.

Life of Protective Coatings

BECAUSE of the great variation in the exposures to which the protective coating on this apparatus is subjected in the manholes, it is difficult to compare the protective quality of the different types of coatings in use. There have been many failures of the protective coating after only a year or two exposure, especially in manholes in which salt and debris remains in contact with the apparatus for long periods of time. Protective coating failures have also been experienced after only a year or two exposure in a smaller number of manholes in which the apparatus is subjected to daily immersion in salt water from nearby rivers. The other extreme are manholes and apparatus which remain comparatively clean and dry most of the time, with the result that the protective coating still remains in good condition after as much as twenty-three years of service.

Figure 5 shows the corroded condition of a network unit after ten and one-half years of service in a manhole. The manhole in which this network unit was installed has no drainage facilities and is located in an area where the streets are frequently flushed with water. These conditions brought about a situation whereby at least the lower portion of the network unit was under water and in contact with accumulated mud and debris an appreciable portion of the time.

Figure 6 shows in more detail the heavy corrosion on the lower portion of one end of the transformer tank. After the corrosion had been removed, this unit showed a maximum loss of about ⅛″ of metal.

Figure 7 shows the corroded condition of another network unit after eighteen years of service in a manhole. The manhole in which this network unit was installed has no drainage facilities and is located where it is susceptible to drainage from the street as well as from the subsurface. This manhole occasionally retains water four to five feet deep, the level marks of which are evident.

Figure 8 shows in more detail the corrosion on the lower portion of the transformer tank and especially at the bends of the cooling tubes, which is usually where the corrosion is found to be most severe. After the corrosion had been removed this

network unit showed a maximum loss of about 1/16″ of metal.

Repainting

FIGURE 9 shows a network unit which had been removed from the system and from which all corrosion and all of the old protective coating have been removed by steel grit blasting preparatory to repainting. All submersible type transformers and network protectors are prepared for repainting in this manner. This work is done in the transformer repair shop of the Consolidated Edison Company of New York, Inc.

Figure 10 shows the equipment used for repainting network units by the flow method. This has been found to be the only practicable method of application because of the complicated form of the apparatus. The equipment consists of a paint drain pan, paint mixer, pump, hose, nozzle and an exhaust system. This equipment is located in the transformer repair shop of the Consolidated Edison Company of New York, Inc.

A typical network unit being repainted is shown in Figure 11. Three coats of a modified coal tar paint are used and the first coat is applied immediately following the cleaning of the steel surface. The network unit is placed in the center of the paint drain pan, which is on a slope and has a sump at the lower end. The batch of paint to be used is thoroughly mixed in the paint mixer with the necessary thinners added to obtain the proper viscosity. A few pounds pressure of compressed air is then introduced and maintained in the paint mixer to cause the paint to flow through the hose and nozzle. The paint is then flowed over the sides of the transformer tank and network protector housing. While the excess paint is draining from the sides, the cover of the transformer tank and top of the network protector housing are painted by brush, since the slope of these areas is not enough to permit the drainage required of flow painting. The unit is then raised above the pan and the bottom portions are flow painted. As soon as the paint stops dripping, the unit is moved away from the pan and the paint is allowed to air dry for at least twelve hours before the succeeding coat is applied. The paint which drains into the pan is then pumped back into the mixer and made ready for reuse. The total film thickness of three coats of this paint is about six mils.

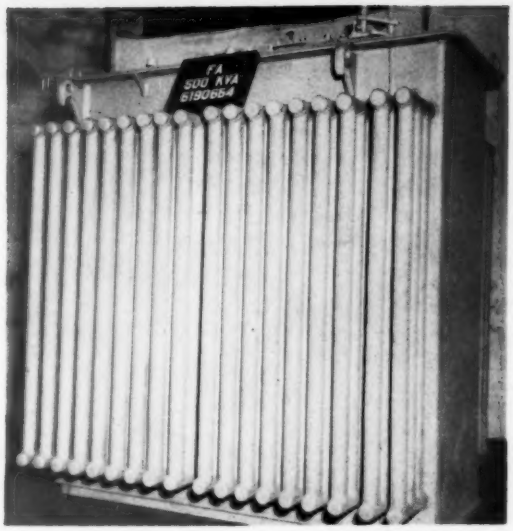


Figure 9. Appearance of network unit after steel grit blasting.

The modified coal tar paint has been used for repainting this apparatus for about fifteen years. This paint has been found to be the most suitable for this use by tests which have been made on a large number of paint systems recommended for this purpose. Experience with this paint compares very favorably with that of other paint systems which were originally applied by the manufacturers of the apparatus.

Paint Tests

IN order to make accelerated comparative tests on new paint systems as they become known, a spe-

Figure 10. Equipment used for repainting network.

Figure 11. Unit undergoing repainting operation.

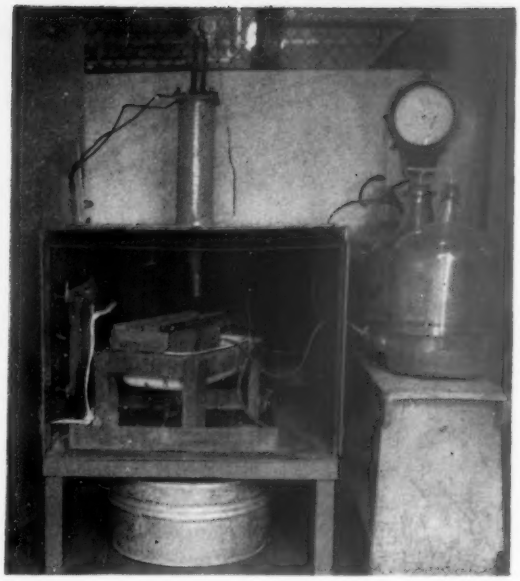


Figure 12. Test equipment showing panels suspended in salt solution.

cial test procedure has been developed by the Consolidated Edison Company of New York, Inc. and is used for this purpose. This test procedure was designed to simulate the exposures encountered in actual service and the results of these tests have been substantiated by those of actual exposure in tidewater manholes. The test consists of alternately immersing steel panels, coated with the paint to be tested, in a one per cent salt (NaCl) solution. During this procedure, the panels are enclosed in a chamber which is maintained at a temperature of 60° to 65° C.

Figure 12 shows the equipment used for this test. The test panels are suspended in a shallow tank and the salt solution is introduced into the tank at a controlled rate which allows the solution level to rise to within one inch of the top of the panels in twelve hours. The solution is then gradually drained from the tank during the next twelve hours. This cycle is repeated until failure of the coating occurs. Duplicate test panels are used and during the test periodic measurements are made of the electric resistance of the coatings. Coatings, which have a low initial electrical resistance as well as those which show an appreciable reduction in resistance during the first days of test, invariably fail after only a comparatively short duration of the alternate immersion test. After a ten day period has elapsed, a sharp cut in the form of a cross is made in the center of one face of one test panel, exposing the base metal, and the alternate immersion test is continued. These cuts are made to simulate fractures which may occur during installation and operation of the apparatus and thereby give an indication of the manner in which the resulting corrosion will spread. During the test, periodic observations are made to determine the condition of the coatings and their protective qualities. Of the large number of paint systems tested, only a few have withstood this test for more than 150 days and those few only by a small margin.

As new coatings become known, they are subjected to comparative tests in the laboratory and to date over one hundred paint systems have been tested. A few vinyl paint systems have been tested, and while they have been found to provide good protection at a temperature of about 60° C., it is questionable that they will be satisfactory for use on this apparatus from the standpoint of operating temperature and method of application. Several transformers having tanks coated with vitreous enamel were purchased and placed in service for test and this coating did not give protection equal to that provided by the modified coal tar paint. This enamel coating appeared to be porous and allowed widespread corrosion on areas of the tanks which had been subjected to immersion. Various types of sprayed metal coatings have been tested and found to be porous and therefore unsuitable for this application. Surface preparations of the phosphate type have also been tested and found to be of no particular advantage on the steel-grit-blasted surfaces.

Cathodic Protection

IN some manholes where the apparatus is subjected to electrolytic conditions due to stray railway current or galvanic currents within or external to the manholes, cathodic protection has been used on an experimental basis to supplement the protective coating, and thereby prevent electrolytic corrosion on areas of the apparatus which were not adequately protected by the coating. Both magnesium and zinc anodes properly located in the manholes and connected to the apparatus have been used to provide this protection. Iron electrodes have also been used with small rectifiers to supply the required current. Cathodic protection has been found to have its limitations which, to some extent, are governed by the resistivity of the water. The latter has been found to range from approximately 50 to 2,000 ohm-centimeters in the manholes. The current supplied for cathodic protection must be carefully regulated in each installation to avoid removal of the protective coating from the apparatus. This necessitates a tailor-made installation to meet the conditions encountered in each manhole. The development of cathodic protection has not as yet been completed for general application and is still under investigation.

There is a very definite need for a protective coating for this apparatus that is far more durable than any of those now in use. Such a coating would make for more dependable operation of the apparatus and would appreciably reduce the present high cost of maintenance. It would also result in an increase in the serviceable life of both the transformer tanks and network protector housings.

This paper has been presented to outline the problem with the hope of stimulating interest and discussion which will eventually result in the development of a much more suitable protective coating for submersible type transformers and network protectors.

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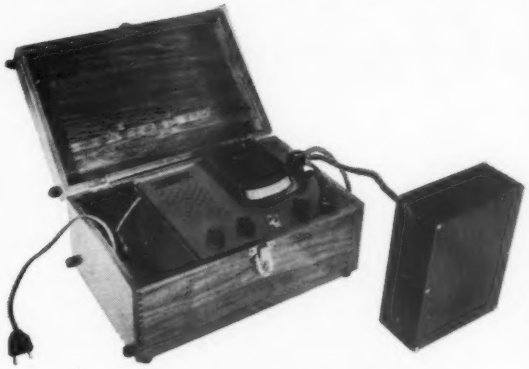

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according to ASTM D523-49T
on paints, varnishes, and lacquers

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in accordance with Federal Specifications TT-P-141b

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perfect performance
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Backed with an outstanding World War II service record, Falkyd Resins step to the front in the mobilization program. As key raw materials, they play a vital part in the manufacture of a wide variety of finishes and protective coatings including those for tanks, ships, ammunition, aircraft and jeeps.
If you have an Army or Navy Specification to meet . . . the facilities of our laboratory and staff are at your disposal . . . to help find the right Falkyd Resin to meet your specification requirement.
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Purecal saves pigment

PURECAL* is an extender with pigmenting properties. Unlike ordinary extenders, Purecal contributes to a paint's opacity and brightness. That's why you can extend or partially replace titanium dioxide and other scarce and high-priced pigments with Purecal M.

Without any loss in quality, and at lower cost, you'll make more gallons of quality paints from the same amount of scarce materials . . . with Purecal.

And because Purecal improves smoothness and dispersion, and decreases grinding time, you get a greater output from the same equipment. We have prepared some charts showing how Purecal compares with other light-colored pigments. They are yours for the asking.

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Hydrogen • Dry Ice • Synthetic Detergents
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For Light Color Alkyds!

HARDESTY offers 2 ALKYD RESIN GRADES of Soya Bean Fatty Acids

HARDESTOIL 15

Titre	(73.4 - 78.8° F) 23.0 - 26.0° C
Color-Gardner Standards 1933	3 - 5
Iodine Value (Wijs)	minimum 125
Free Fatty Acid (as oleic)	98 - 100%
Acid Number	195 - 199
Saponification Value	196 - 200
HEAT STABILITY: After heating to 235° C for five hours with CO_2 Color-Gardner Standards 1933	5 - 7

HARDESTOIL 16

Titre	(42.8 - 48.2° F) 6.0 - 9.0° C
Color-Gardner Standards 1933	3 - 5
Iodine Value (Wijs)	minimum 135
Free Fatty Acid (as oleic)	96 - 98%
Acid Number	191 - 195
Saponification Value	192 - 196
HEAT STABILITY: After heating to 235° C for five hours with CO_2 Color-Gardner Standards 1933	5 - 7

The light color of every drum of Hardestoil 15 and Hardestoil 16 proves their superior advantages in alkyd resins for protective coatings. Hardestoil 15 is specially formulated for use in production of rapid-drying, high gloss, durable primers, surfacers, outside and interior enamels, finishes and water emulsion paints. Hardestoil 15 and Hardestoil 16 bring new adhesive and weather-protective values to your coating, and offer increased protection economically. Where high iodine and low titre are requisites, specify Hardestoil 16.

EACH LOT LABORATORY-TESTED

Because even precise controls do not always insure quality in alkyd manufacturing, W. C. Hardesty Company applies special laboratory tests to every lot of Hardestoil 15 and Hardestoil 16, to be sure clarity and color are consistently superior.

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Available in 55 gallon special lined drums.

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FACTORIES; DOVER, OHIO TORONTO, CAN.

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GARDNER LABORATORY

DRY THICKNESS GAGE

Simple and Accurate

For measuring the thickness of attached films of protective and decorative coatings as well as unsupported films of plastic, paper, etc., the Gardner Thickness Gage is offered. According to the manufacturer, this gage provides a means for measuring dry film thickness with comparable accuracy and simplicity. The readings are direct and can be used on curved surfaces as low as 5 inches in radius without introducing more than 0.10 mils error. For further details write to Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda, Md. PVP—March.

LUBE CART

Self-Contained Unit

Small, compact, easy to push unit can be moved rapidly along plant aisles and between closely placed machines. No air supply is required; it is equipped for high pressure or volume greasing. Grease and oil are dispensed through 10 feet hoses. Graco Products, Gray Co., Graco Sq., Minneapolis 13, Minn. PVP—March.

BLADE APPLICATOR

For Wedge Films

The special wedge-shaped applicator has been designed primarily for control of wrinkle finish production. The applicator has clearances from 0 to 6 mils on one side and 4 to 10 mils on the obverse side. Contact face clearances are stamped on the ends of the applicator. The gate length of 6″ provides a one mil gradient per inch of blade length. Whey laying down wrinkle-type coatings, this type blade affords a rapid means of determining the required wet film thickness for the most desirable wrinkle-finish effect. Gardner Laboratory Inc., Bethesda, Md. PVP—March.

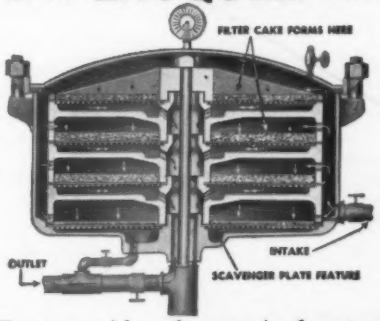
LOAD-LIFT

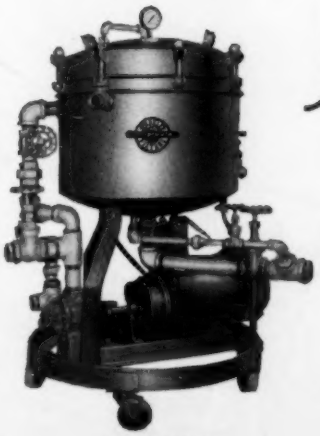
All Aluminum

Designed and engineered especially to cut working time, the only aluminum single-unit oil tank and pump combination enables the new Lightning Load-Lift to raise loads 25% easier and 25% faster.

Radical also is the new design by which the truck is lowered by a simple right-angle flick of the handle. This innovation completely eliminates stooping or bending to lower the loads. The truck raises and lowers with the same lifting handle while the operator stands. He does not need to bend at any time. The Market Forge Co., Everett, Mass. PVP—March.

CLARIFY VARNISH and LACQUER with... SPARKLER horizontal plate FILTERS



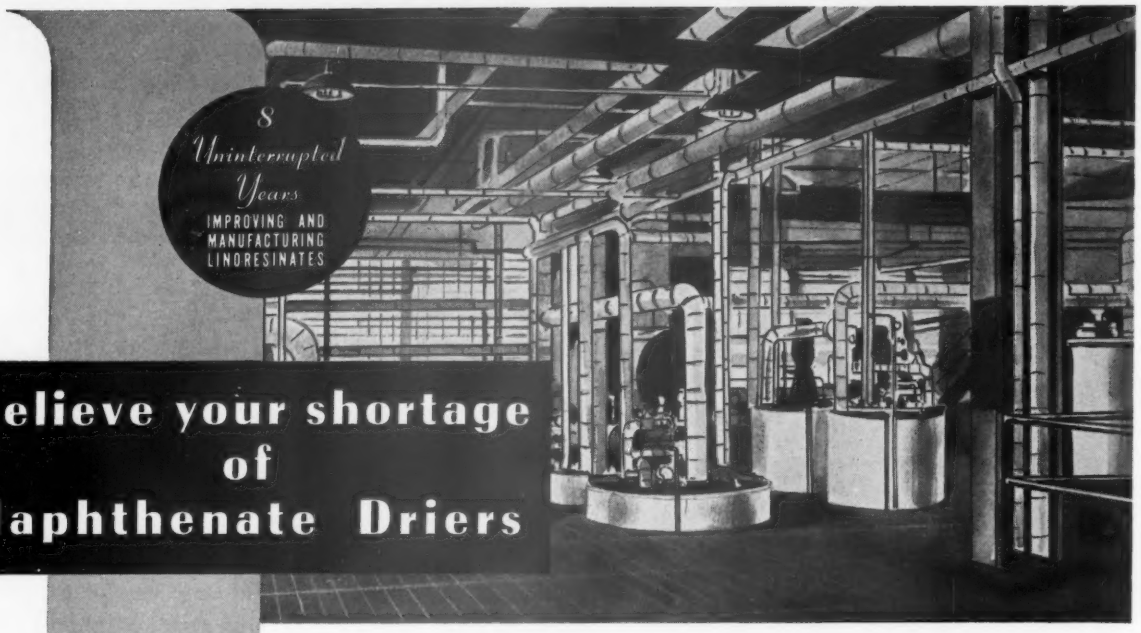


Model 18-S-12 Varnish Filter in mildsteel (steam jacketed)

Every varnish maker can (and most of them do) use a Sparkler Filter to improve the clarity and brilliance of varnishes, lacquers and other clear liquids by removing "fish-eyes," skins, and other incidental solids and semi-solids.

We invite correspondence on any special problem related to either of the above processes. Our engineers are ready to give you the benefit of years of experience in this field.

SPARKLER MANUFACTURING COMPANY, Mundelein, Illinois



Relieve your shortage of Naphthenate Driers

Harshaw's

RECENTLY IMPROVED LINORESINATES

Maintaining your maximum production capacity is facilitated by quick adoption of Harshaw's newly improved Linoresinate Driers. Transition from naphthenates to these newly improved Linoresinates can be accomplished with a minimum of interruption.

Because their metal content is identical with that of conventional naphthenates, Harshaw's Linoresinate Driers are worthy replacements for naphthenates in your formulations on a pound for pound basis. Not only does their excellent overall drying performance compare with that of naphthenates, but they have outstanding stability in paint and varnish vehicles, as well as in storage.

Since early in the years of World War II, Harshaw has manufactured and improved its Linoresinate driers. Our manufacturing facilities have been improved too . . . Harshaw Driers are produced with up-to-date equipment in a large new factory.

Rush me a test sample of _____

My Name _____

Co. Name _____

Address _____ Zone ____ State ____

City _____

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1945 East 97th Street, Cleveland 6, Ohio
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HARSHAW'S LINORESINATE DRIERS

COBALT LIQUID 6%	LEAD LIQUID 24%
COBALT LIQUID 4%	LEAD LIQUID 16%
MANGANESE LIQUID 6%	MANGANESE LIQUID 4%
IRON LIQUID 6%	

NEW PRODUCTS

BAKER INDUSTRIAL

DRUM CLAMP

For All Type of Drums

To permit easy handling of cylindrical objects either individually or as unit loads on pallets, a new drum clamp is offered. The device picks up individual steel drums, steel or wooden barrels, cardboard drums or any other cylindrical material and loads a pallet which is then handled after two-rubber-faced grab plates are removed from the forks. Baker Industrial Truck Div., Baker Raulang Co., 1250 W. 80th St., Cleveland 2, Ohio. PVP—March.

BUTYLENE GLYCOL

Versatile Intermediate

This new Celanese product, a high boiling solvent and coupling agent, can be used as a humectant, solvent and lubricant in the textile, paper coating, and printing paste.

Celanese Butylene Glycol is also a versatile intermediate for surface active agents, alkyd resins and rosin esters and allows the production of polyester plasticizers with high dielectric constants for use in electrical insulation compounding. Celanese Corp. of America, 180 Madison Ave., New York 16, N. Y. PVP—March.

GRAVITY RAMP

Roller-Type

Gravity operated loading ramp is furnished in either roller or wheel types in standard lengths of 10 feet. They are equipped with grab hooks to prevent slipping on the truck bed. This ramp will accommodate medium heavy flat based objects and when used with a board or pellet will handle bags, crates or drums. Metzgar Co., 449 Douglas St., NW, Grand Rapids, Mich. PVP—March.

SILICONE ALKYDS

Commercially Available

Three silicone alkyd coating resins, first chemically combined silicone alkyds resins is commercially available. In addition to the advantages of availability and the resins' imposing list of properties; the prospect of a low-price range is suggested by the Plaskon announcement.

The resins, designated Plaskon ST-856, ST-873, and ST-881 silicone alkyd resins, are expected to find wide use in military applications because of their important properties, particularly heat resistance, and including excellent resistance to weathering, humidity, chemicals and salt spray; plus satisfactory performance under widely varying climates. Expected uses for silicone-alkyd resins will be in coatings for space heaters, transformers, motors, chemical and refinery equipment, ships, utility towers, containers, electric roasters, automotive exhaust pipes, sunlamps, surgical sterilizers, X-ray equipment, refrigerators, stove and stove hardware, exterior signs and steam radiators. Plaskon Div., Libbey-Owens-Ford Glass Co., Toledo, Ohio. PVP—March.

formulate with

ETHYL BUTYL KETONE

A DISPERSANT—Aids resin dispersion in vinyl organosols. Medium evaporation rate of ethyl butyl ketone retards film cracking and facilitates fusion.

A SOLVENT—Effective solvent for VINYLITE resin VYHH. Particularly useful in nitrocellulose lacquers and synthetic coatings requiring a medium-to-high-boiling ketone.

PHYSICAL PROPERTIES

Formula	$C_4H_9COC_2H_5$
Boiling Point at 760 mm. Hg	147.8°C.
Toluol Dilution Ratio at 20°C. ½ sec. R. S. Nitrocellulose	2.6
Evaporation Rate (Butyl Acetate = 100)	40

Available in commercial quantities

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30 E. 42nd St., New York 17, N.Y. Offices in Principal Cities
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If your job involves color formulation and the selection of pigments, you'll welcome the useful information contained in these handy technical reports. They've been prepared by Williams to make it easier for you to quickly select a pigment having chemical and physical properties which hit your color specifications "on the head".

Each report describes the origin of the pigment, how it is made, its chemical and physical properties, and its applications. The reports cover Pure Red Iron Oxides, Pure Yellow Iron Oxides, Chromium Oxides, Venetian Reds, Siennas and Umbers, Metallic Browns and others.

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EMPLOYING NON-FADING GLASS COLOR STANDARDS

Modern Apparatus for Precision and Accuracy in Color Determinations of Varnish, Oils, Resins, Nitro-Cellulose Lacquers, and Similar Transparent, Colored Liquids.

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NEW PRODUCTS

HOLT

PAINT MIXER

For Laboratory Use

Fast and thorough blending and mixing action characterizes this paint mixer.

The mixer will take any size container, from a quarter-pint to a full gallon, either metal or glass, simply by lifting the spring clamp by its big handle, placing the container in the cradle and flicking the switch.

It comes fully equipped, ready to plug in any outlet, with 15 feet of cord, heavy duty safety toggle switch, heavy duty 1/3 h.p., 115/230 volt, 60 cycle motor, and a heavy duty, long life V-belt.

Laboratories use this unit for mixing either wet or dry ingredients in glass or metal containers. Complete information may be had by writing to Holt Manufacturing Company, 651 20th Street, Oakland 12, California; or 272 Badger Avenue, Newark 8, New Jersey. PVP—March.

BALL MILL

Prevents Settling

A vibratory ball mill recently constructed by the National Bureau of Standards is expected to provide highly efficient reduction and blending of a variety of commercial materials. Materials for which this mill is expected to have application are pigments, ceramic materials, metal powders, resins, etc. The mill design prevents material from settling to the bottom of the jar. For further information write to the National Bureau of Standards, Washington 25, D. C. PVP—March.

COBALT DRIERS

Emergency Suggestions

Since it is apparent that there will not be sufficient cobalt for all of your requirements, may we suggest you conserve your cobalt drier supply by considering the following:

1. Outside paints. It is thought that cobalt can be replaced with one and one-half to twice the quantity of Manganese.

2. Other type finishes. It may not be possible to eliminate cobalt entirely, and still maintain drying schedules, but usually it may be reduced by about 50% by substituting increased amounts of Manganese and the use of some Calcium.

3. In many instances, less Cobalt will perform satisfactorily provided increased quantities of Lead are used. The initial set may be retarded if the ratio of through drier to top drier is too large.

4. Where Cobalt is used alone, as in some alkyds, *reduced* Cobalt content may be achieved by adding Calcium metal at about double the weight of Cobalt replaced.

5. Keep in mind that Iron might be useful as a substitute for Cobalt in dark colored baking finishes.

For further information write to the Harshaw Chemical Co., 1945 East 97th St., Cleveland 6, Ohio. PVP—March.

HOW TO ASSURE YOUR MAXIMUM SUPPLY OF COBALT DRIERS UNDER M-10

Under NPA's amended M-10 directive, *drier manufacturers* are allocated the amount of cobalt metal they may convert into and ship as driers each month. Allocations are based on the essentiality of the end-product use to the defense program and the welfare of the American economy.

Therefore, when Nuodex applies to NPA for cobalt metal to process into driers to fill *your* requirements, we much rely on *you* for two important facts: (1) the *quantity* of cobalt driers you need for the forthcoming month; (2) the *end uses* of the products to which you will add these driers.

So we may help you most, place your cobalt drier order for each month by the 5th of the preceding month—that is, order your requirements for April by March 5th, for May by April 5th, etc. Also, show what percentage of your order will go for each of the following end-uses—D.O. ratings; Indirect Defense; Essential Civilian broken down according to public health, transportation, communication, agricultural implements, printing inks; and Civilian such as trade sales and similar decorative coatings.

Receive the maximum cobalt drier to which you are entitled. Cooperate fully. Send us your monthly orders with complete end use data—promptly!

*If you're not receiving Ye TOWNE DRIER, just contact your Nuodex Agent. He'll put you on our mailing list.

NUODEX PRODUCTS CO., INC.
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ROLE OF VEHICLES

(*From page 16*)

mechanical anchorage and specific adhesion (8, 9). Mechanical adhesion results from the penetration of the paint or vehicle into the crevices and pores of the substrate surface followed by drying and solidification. Specific adhesion is the result of the interplay of residual molecular forces causing attraction between the vehicle and substrate molecules.

The fraction contributed to the total adhesion force by mechanical anchorage is relatively small. It is obvious that it must bear the same relationship to the cohesional strength of the film as the sum of the cross sectional areas of all tendrils bears to the total film area. In the extreme, it can only approach the cohesional strength of the film as a limiting value as the sum of the cross sectional areas of the tendrils approaches the total interfacial area between the film and the substrate surface.

By far the most important contributor to film adhesion is the molecular force of attraction operating between the molecules of the film matrix and the substrate surface. This force is very largely a function of the concentration of polar groups capable of being adsorbed on or entering into chemical reaction with the molecules of the substrate surface. It is obvious that the concentration of such polar groups is relatively high in suitable monomers or polymers of a low degree of polymerization. Materials of this sort, however, possess insufficient cohesive strength to yield suitable film systems. At the other end of the scale are found the high molecular weight compounds which have been formed by the mutual interaction of polar, reactive centers and which, therefore, do not contain a sufficient concentration of free polar groups to insure the desired degree of specific adhesion. On theoretical grounds, therefore, compounds of a medium degree of polymerization should be preferable because they combine adequate cohesive strength with a sufficient density of polar groups.

There is another factor which limits the degree of polymerization of the vehicle. No substrate surface is absolutely smooth and free from pores. In order to obtain a maximum of adhesion, it is necessary that the vehicle penetrate into all of the pores of the substrate surface. Its viscosity must be such that bridging of such pores is avoided, for this would result in a definite weakening of the adhesion. Only when the vehicle or paint possesses the appropriate flow characteristics is it possible to fully utilize the benefits to be derived from the roughness or porosity of the substrate surface. The increase in adhesion obtainable in this manner is directly proportional to the increase in the area of contact between the substrate surface and the paint film.

On the basis of what has been said so far, it can be safely stated that adhesion forces cannot operate properly and effectively unless intimate contact is established between the paint and the substrate, that is, unless the paint wets the substrate surface and displaces from it any absorbed moisture, air or other foreign substances. It has been demonstrated that this ability to wet a metal surface is a direct function of the polarity of a paint vehicle, that is the presence of groups capable of being strongly attracted by the metal surface and, in the extreme, able to react chemically with it. Unfortunately, the presence in the vehicle or film binder of a high concentration of such polar groups will not only promote adhesion but will also materially lower the coating's resistance to water and other corrosion factors. Again, the paint formulator is confronted by the ubiquitous problem of finding the best compromise between opposing effects and his suc-

Look what's happened

TO THE

HOT-LACQUER PROCESS

EVER SINCE CSC dedicated the hot-lacquer process (U. S. Patent No. 2,150,096) to the lacquer industry, growth of its use has been outstanding.

Hot lacquer is going on such varied items as automotive parts, furniture, furnaces, tool boxes, wall tile, caskets, pianos, aircraft equipment, scales, and washing machines at the rate of over 250,000 gallons per month!

The many advantages? Preparation time is shortened. And spraying time, too, with fewer coats required. Less tendency to sag. Elimination of blushing. Less spray dust. Less sanding and polishing. Labor and material savings. Higher quality of finish.

To put the money-saving, time-saving hot-lacquer process to work for you, see your lacquer supplier. He's ready to serve you.

CSC

INDUSTRIAL CHEMICAL DIVISION

COMMERCIAL SOLVENTS CORPORATION

17 East 42nd Street, New York 17, N. Y.

cess is measured by the skill with which he discharges this responsibility.

References

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SURFACE PREPARATION

(*From page 22*)

face profile. Proper and constant distance between work and blast nozzle will help to produce a uniform anchor under ideal condition. If blast abrasives are recirculated, the dust, the fines, and coarse particles, must be removed to prevent changes in the profile.

4. How can the coating thickness be measured under shop conditions when applied over grit or shot blasted surfaces?

Method one employs the electronic instrument, with a direct or indirect reading gage. Method two employs either the Krouse or Elcometer magnetic pocket size gage. The elcometer must be calibrated and the reading made direct. The Krouse gage must be read from a second unit, a special tapered scale, after the thickness of the paint has been established on a threaded magnetic gage. One can also hang up a test panel along some part of the machine and apply regular spray thickness and use a micrometer for checking.

5. To what extent in practice do wash primers actually replace special chemical pretreatment?

As long as wash primers are found compatible with the succeeding prime or finish coat, their performance has been equal or superior to the standard phospohoric chemical pretreatments on structural work. Beside the surface conversion of the pretreatment, the wash primer adds a vinyl film to the metal to which most coatings will adhere. There has been some slight reaction with some wash primers when used in fresh water service. Porosity blisters appeared under some coating systems that were tested in waters of the Monongahela and Ohio Rivers around Pittsburgh. The blister is not serious.

•

Rubberset Names Daggatt To Vice President Post

Elwood M. Jones, Jr., President of Rubberset Company, manufacturers of paint and shaving brushes and paint rollers, has announced the appointment of Walter R. Daggatt, General Sales Manager, to the post of Vice President in charge of Sales.

ACS Paint and Varnish Div. Spring Meeting Program

The American Chemical Society, Div. of Paint, Varnish and Plastics Chemistry has outlined the program of its Spring meeting to be held April 1–5 at the Bradford Hotel, Boston, Mass.

The feature of the April 3rd session will be a symposium entitled, "Developing Markets Through Paint, Plastics and Printing Inks in Packaging". G. M. Kline will preside. R. W. Auten will preside at the April 4th meeting at which a symposium on "Urea, Melamine and Related Resins" will be held. On April 5th several papers on paint and varnish will be given with F. Scofield presiding. General papers on plastics, E. E. McSweeney presiding, will also be presented on that same day.

The sign of ECONOMY for
HYDROCARBON RESINS

PANAREZ

Everyone has problems. We sympathize with yours, and suggest that if you need quality resins, it is important for you to investigate economical **PANAREZ** resins ***today.*** Those production problems don't seem quite so big—when **PANAREZ** resins are specified.

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DIVISION
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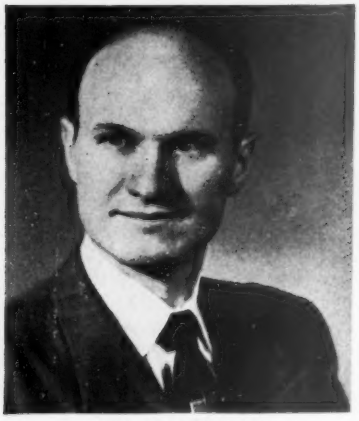
Texas City, Texas

JOHN A. MCKINLEY

Metals Disintegrating Sales Appointments

Metals Disintegrating Company, Inc., Elizabeth, N. J., manufacturers of metal pigments, metal powders and metal abrasives, has announced the promotion of John A. McKinley to the position of Pigment Sales Supervisor.



JOHN P. HALLORAN

John P. Halloran has been appointed to succeed Mr. McKinley as manager of the company's Chicago office. A graduate of Illinois Institute of Technology, Mr. Halloran has had considerable experience in the paint, varnish and ink industries, in his former position as assistant chief chemist, F. A. Stresen-Reuter and Co.

•

Raymond C. Gaugler Elected President of Am. Cyanamid

Raymond C. Gaugler, fifty-eight, was elected president of American Cyanamid Company. He succeeds the late William B. Bell, who died suddenly on December 20, 1950. Mr. Gaugler has been a Director of the Company since 1929 and has served as Executive Vice President since his appointment to that position on October 23, 1947.

•

Atlas Mineral Products Co. Announces Appointments

Mr. George L. Wirtz, president of the Atlas Mineral Products Company, Mertztown, Pennsylvania, has announced the following personnel appointments in keeping with the expansion program at Atlas.

Mr. Donald F. Deakin has joined the Atlas organization as water and sewer products director. Mr. Deakin is a graduate of Penn State with a degree in civil engineering.

Mr. Newton O. Duncan, Jr. a recent graduate of Texas A & M College has joined the Atlas Products Company and has been assigned to the Houston office.

•

National Safety Council Names C. F. Alexander

Charles F. Alexander has been named manager of the Industrial Department of the National Safety Council.

Mr. Alexander, who has had extensive industrial experience in the fields of production, engineering, foreman training and sales, joined the Council after five years with the Cherry-Burrell Corp., Chicago. His most recent position there was as assistant general manager of manufacturing, with duties including the coordination of production methods and defense contracts.

R-B-H

IS READY TO *sign up*

We are all set for industrial mobilization now. We want to do what we know how to do best—make pigment dispersions.

Consult us in your development work to meet government specifications. Our dispersion technicians are on call. Our laboratories are at your disposal. Our plant can make a gallon or fifty drums.

R-B-H . . . *for finishes of integrity.*

R-B-H *Dispersions*

DIVISION OF INTERCHEMICAL CORPORATION
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ARNE OLSON

Blaw-Knox Company Forms Resins and Plastics Dept.

Chemical Plants Division of Blaw-Knox Company has announced the formation of a Resins and Plastics Department, and the appointment of Arne Olson as manager of this unit.

The new department headed by Mr. Olson will specialize in the design and construction of complete plants for the manufacture of all types of synthetic resins, including alkyds, phenolics, urea, melamine, polyvinyl chloride, and polystyrene.

•

JOHN T. LAUDER

New Technical Director For O'Brien Corporation

Jerome J. Crowley, Jr., president of The O'Brien Corporation, announces the appointment of John T. Lauder as O'Brien's technical director at the O'Brien South Bend plant. Mr. Lauder is a graduate of Wayne University where he received his B.S. degree in Chemical Engineering in 1928.

Upon graduation Mr. Lauder went to work for O'Brien where he got his early training in the O'Brien laboratory. After two years he resigned to take a position with the Rinshed-Mason Company of Detroit where he specialized in varnishes and alkyd enamels.

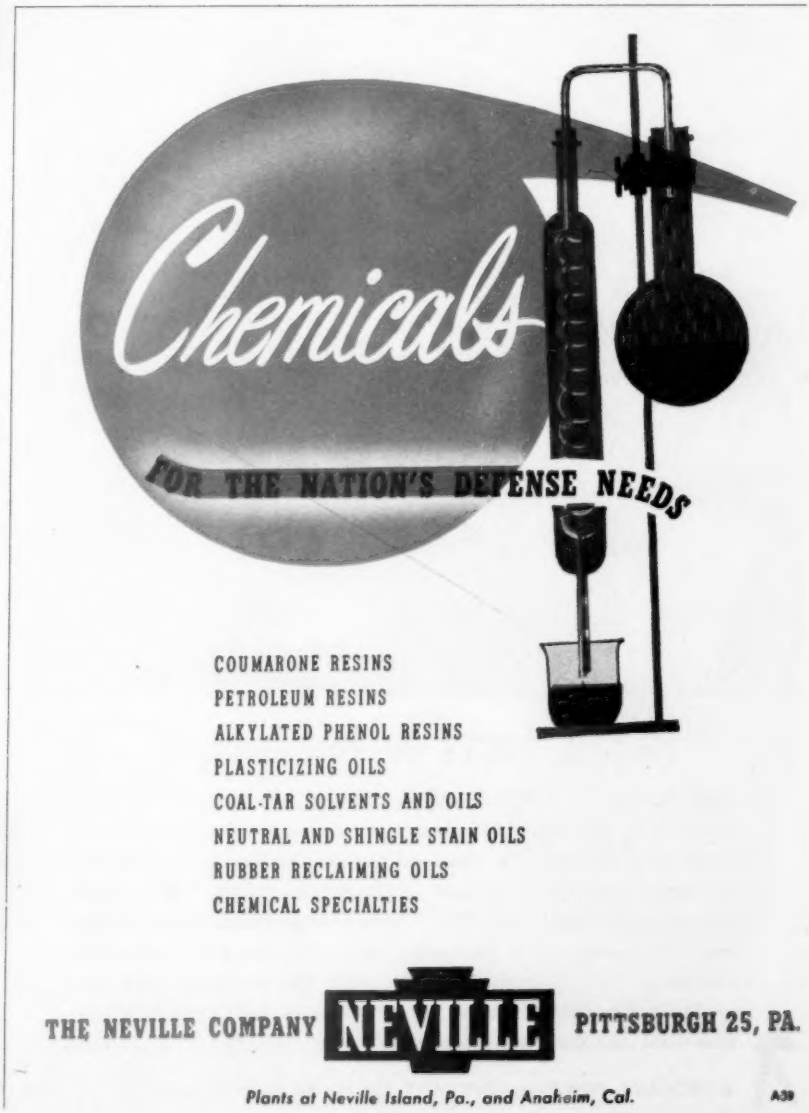
In 1942 Mr. Lauder was called into the navy and served most his time in testing and experimental work at the Naval Air Experimental Station in Philadelphia.

Upon return to civilian life, Mr. Lauder served three years as production manager of the Atlantic District of Finishes Division of the Interchemical Corporation. In 1949 he resigned to become a partner in the Delta Laboratories in Coral Gables, Florida, which was founded to provide consulting services and to do manufacturing of industrial finishes. As consultants, Mr. Lauder and Mr. "Dutch" Johnson spent five months in Italy last year setting up and placing in operation a new paint plant of Fiat, named Industries Vernici Italiene.

•

A. J. Falkenberg to Speak at National Oil Mills Meeting

Arthur J. Falkenberg of American Mineral Spirits Company, Western has been invited by the National Oils Mills Association to give an address at their meeting which is being held March 10th and 11th at Los Angeles. His address will concern Solvent Extraction of Vegetable Oils. A. J. Falkenberg is secretary and treasurer of American Mineral Spirits Company, Western and Manager of Amsco's west coast subsidiary.



TECHNICAL Bulletins

CATIONIC CLEANER

Bulletin #11 is a six page report describing Cationic Acid Cleaner developed by Refined Products Corp., Manufacturing Chemists of Lyndhurst, N. J.

Results of corrosion tests are given together with a discussion of the test method used. Considerable attention is given to the use of this cleaner in the metal cleaning field employing the "wipe-on" method.

ALUMINUM SILICATE

Series of aluminum silicate pigments and their use as fillers or inerts in paint manufacturing are described in several one page bulletins issued by Edgar Brothers Co., Metuchen, N. J. Important properties are listed and the effect of aluminum silicate in improving the various properties of protective coatings are discussed in detail.

NEVILLAC PLASTICIZERS

Specification and properties, solubility, compatibility and uses of Nevillac TS Plasticizers are covered in Technical Service Report No. 7-A issued by The Neville Co., Pittsburgh 25, Pa.

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COLLOIDAL EQUIPMENT

Eppenbach, Inc., 45–10 Vernon Blvd., Long Island City, N. Y. has released a catalog on the company's "QV" series of colloidal equipment for emulsifying, mixing and grinding. Graphs and photographs are also included.

GRINDING & MIXING

The U. S. Stoneware Co. has recently issued Bulletin 265 covering the firm's line of grinding and mixing equipment. Various types of jar mills, drum rollers, tumbler and tubular grinding media are illustrated and described. The U. S. Stoneware Co., 60 E. 42nd St., New York 17, N. Y.

STRIPPERS

Four page bulletin describes various strippers for removal of synthetic organic coatings from metals. Lacquers, varnishes and enamels are discussed. Emulsion, room temperature, fast evaporating types are discussed. Enthone, Inc., 442 Elm St., New Haven, Conn.

MONTAN WAX

Government bulletin discusses montan wax and its use in polishes, electrical insulating compounds, inks, and protective coatings. Properties including melting point, saponification and ester values, specific gravity are also given. Copies of Bulletin 482 may be obtained by remitting 35 cents to Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

PAINT HEATERS

A new 8-page bulletin for Bede Products Inc., 4311 Ridge Road, Cleveland 9, Ohio, gives full information on the complete line of Bede Paint Heaters. Information about the new Hot Spray process, heating paint to elevated temperatures before spraying, is also given.

one more good reason
HOT-SPRAY LACQUER
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Latest Developments in Hot-Spray Lacquer
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QUESTIONS and ANSWERS about the HOT-LACQUER PROCESS
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PACKAGING AND PAPER LACQUERS
THE CASE FOR THE HOT-LACQUER PROCESS
THE CASE FOR THE HOT-LACQUER PROCESS

Helpful Facts on Hot Lacquer

Here are a dozen booklets with up-to-date information especially prepared to help you tell industry about recent advancements in lacquer technology. The new and rapidly developing market for hot-spray lacquers is outlined in the survey report, "Who Uses Hot-Spray Lacquer and Why." Other literature describes modern lacquer's merits in the packaging, paper, furniture, and automotive fields. You'll want copies for your files and quantities are available for distribution to your customers. Let these informative sales aids go to work for you.

***HERCULES POWDER COMPANY** 926 Market St., Wilmington, Del.* IC51-2

CALENDAR OF EVENTS

Mar. 7–9. Southern Paint and Varnish Production Club Meeting, Buena Vista Hotel, Biloxi, Miss.

Mar. 13–16. Annual Conference of the National Association of Corrosion Engineers, Hotel Statler, New York City, N. Y.

Mar. 16. Fifth Annual Regional Conference, Protective Coatings Div., Chemical Institute of Canada, Royal York Hotel, Toronto, Canada.

April 17–20. Twentieth National Packaging Exposition of the American Management Association, Auditorium, Atlantic City, N. J.

April 27–28. Annual Joint Meeting of Dallas-Houston Paint and Varnish Production Clubs, Shamrock Hotel, Houston, Texas.

May 24–25. Society of Plastics Industry Meeting, Greenbrier Hotel, White Sulphur Springs, W. Va.

June 18–22. A. S. T. M. Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Oct. 22–24. Thirteenth Annual Forum of the Packaging Institute, Hotel Commodore, New York City, N. Y.

Oct. 29–31. National Paint, Varnish and Lacquer Association Convention, Chalfonte-Haddon Hall, Atlantic City, N. J.

Nov. 1–3. Federation of Paint and Varnish Production Clubs, Chalfonte-Haddon Hall, Atlantic City, N. J. Paint Industries Show, Oct. 31–Nov. 3.

•

John C. Mull Named Vice President of O'Brien Corp.

At their recent board meeting, the directors of The O'Brien Corporation, South Bend, Indiana, elected John C. Mull a vice-president of the corporation. Mr. Mull is production manager of the O'Brien South Bend plant and has been with the company for thirty-three years.

•

Hercules Powder Appointments

Edwin S. Ladley has been named assistant director of purchases of Hercules Powder Company, Lawrence J. Finnan, Jr., director of purchases. He succeeds William L. Hewes, who retired December 31, after 41 years of service.

CLASSIFIED ADVERTISEMENTS

Rates: $.20 per word, except those seeking employment, for which rate is $.10 per word. Minimum: ten words. Address all replies to Box Number, c/o Paint and Varnish Production, 855 Avenue of the Americas, New York 1, New York.

Coating Formulator. Graduate Chemical Engineer with over 3 years experience formulating specialty lacquers and vinyls seeks responsible position in coating industry. New York area preferred. Box 108. *Paint and Varnish Production.*

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Newman Joins Calco

Richard L. Newman, formerly associated with Pabco Products, Inc., has joined the Technical Field Service Division, Pigment Department, American Cyanamid Company, Calco Chemical Division, Bound Brook, New Jersey.

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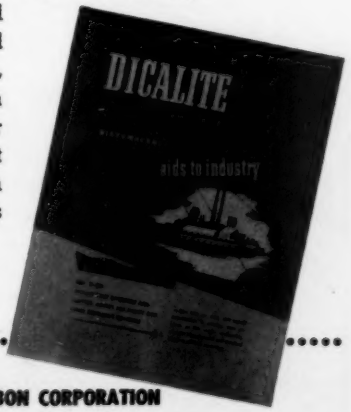

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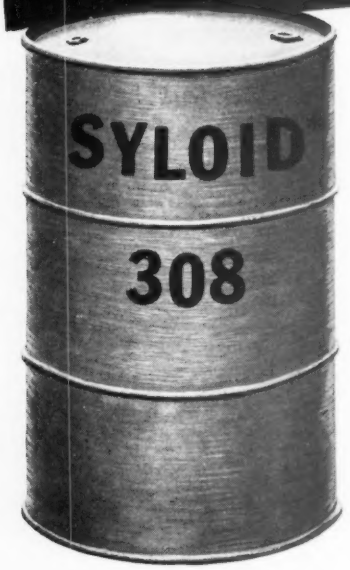

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ADVERTISER'S INDEX

American Can Co. 6, 7
American Cyanamid Company ..... Feb.
Atlas Electric Devices ..... Feb.
Atlas Powder Company ... Feb.

Bakelite Division, Union Carbide and Carbon Corporation ..... Feb.
Barrett Div., Allied Chemical & Dye Corp. ..... Feb.
Binney & Smith Co. ..... Feb.

Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp. 33
E. W. Colledge, G.S.A., Inc. Feb.
Commercial Solvents Corp. . 36
Concord Mica Corp. 42
Continental Can Company .. 17

The Davies Can Co. ..... Feb.
The Davison Chemical Corp. 42
Dicalite Division, Great Lakes Carbon Corp. 41

Elgin Manufacturing Co. ... Feb.
The English Mica Co. ..... Feb.

Falk & Co. 29

A. Gross & Company ..... Feb.

W. C. Hardesty Co., Inc. ... 30
The Harshaw Chemical Co. 32
Hellige, Inc. 34
Hercules Powder Co. 40

Lead Industries Association . 3

Magnetic Pigment Div., Columbian Carbon Corp. ... 4

The Neville Company 39
Newport Industries, Inc. Front Cover
Nuodex Products Co., Inc. .. 35

Pan American Refining Corp., Pan American Chemicals Div. 37
Photovolt Corp. 29

R. B. H. Dispersions, Division of Interchemical Corp. ... 38
Reichhold Chemicals, Inc. 2nd Cover
Charles Ross & Son Company ..... Feb.

Sindar Corp. ..... Feb.
Sparkler Manufacturing Company 31
Sun Oil Co. ..... Feb.

Titanium Pigment Corporation ..... 4th Cover
Troy Engine & Machine Co. Feb.

Union Carbide and Carbon Corporation, Bakelite Division ..... Feb.
Union Carbide & Carbon Corp., Carbide & Carbon Chemicals Div. ..... Feb.
United Carbon Co., Inc. ... Feb.
U. S. Industrial Chemicals, Inc. 8
U. S. Stoneware Co. .. 3rd Cover

Velsicol Corp. 23

C. K. Williams & Co. 34
Wyandotte Chemicals Corporation 29

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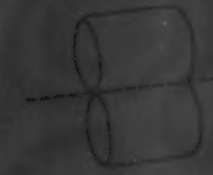

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